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DEHYDRATION OF THE AGAR-AGAR GEL BY ADSORPTION PART 2. DEHYDRATION BY THE "TON PLATTE" (UNGLAZED POTTERY PLATE)

Ikunosuke OKADA, Isamu OSAKABE, Yuji KURATOMI, Takeaki KIKUCHI

(Received on Jan. 21, 1952)

It was reported on the part 1 [1] that it was possible to dehydrate the agar-agar gel by the adsorption of the "Bentonite", without depending on the mechanical processes e. g. refrigeration, hydric pressure, spray dryer or cataphoresis.

Then the authors tried to dehydrate it by the adsorption of the "Ton platte" on this experiment. The results were very effective, and will be available for the industrial purpose.

EXPERIMENTAL

The agar-agar was dissolved in boiling water and cooled to make the agar-agar gel, and cut into thin slices.

The following experiments were tried by the use of this agar-agar gel.

1. Dehydration of the agar-agar gel due to the difference of its concentrations.
2. Dehydration of the agar-agar gel by the influence of its thickness.
3. Dehydration of the agar-agar gel when the moistened "Ton platte" was exchanged for the dried one.
4. Dehydration of the agar-agar gel by the inflnence of the weight.
5. Dehydration when the agar-agar gels and the "Ton platte" were piled one on another.
6. Ingredients of the agar-agar prepared by this "Ton platte" method.
7. The dehydration by this "Ton platte" method was compared with the dehydration of the "Bentonite" method.
8. Ability of the adsorption of the "Ton platte".
9. Dehydration by the influence of the section of the agar-agar gel.
10. Empirical formula of the residual water in the agar-agar gel.

1. DEHYDRATION OF THE AGAR-AGAR GEL DUE TO THE DIFFERENCE OF ITS CONCENTRATIONS

The agar-agar gel containing 1%, 2%, 3% and 4% of the agar-agar was sliced into the size 10 cm. square and 0.5 cm. in thickness.

Then this agar-agar gel was put into between the two pieces of "Ton platte". Then the surface of the plate stuck fast that of the agar-agar gel, and the contact surface formed a vacuum. Soon began the dehydration by the adsorption, and the adsorbed water was dispered into the "Ton platte", thus the purpose of the dehydration was satisfactorily achieved.

In this experiment the "Ton platte" 15 cm. square and 1.0 cm. in thickness was used.

The agar-agar gel dehydrated by the adsorption of the "Ton platte" was weighed each hour, and the percentage of the dehydration was calculated. The results were shown on the table 1, and Fig. 1, 2, 3, and 4.

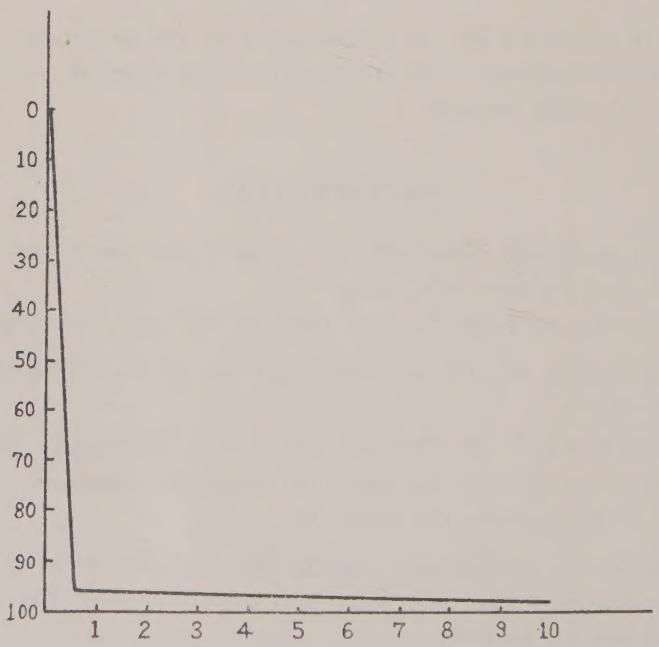

Fig. 1. Dehyration of the gel containing 1% agar agar. (Thickness 0.5 cm.). Ordinate—dehydration ratio; Abscissa—hour.

As shown on the table 1, and the Fig. 1, 2, 3, and 4, the gel containing the 1% agar-agar was dehydrated 96% after 30 minutes, and after it was left alone 20 minutes in the open air, the dried agar-agar was obtained.

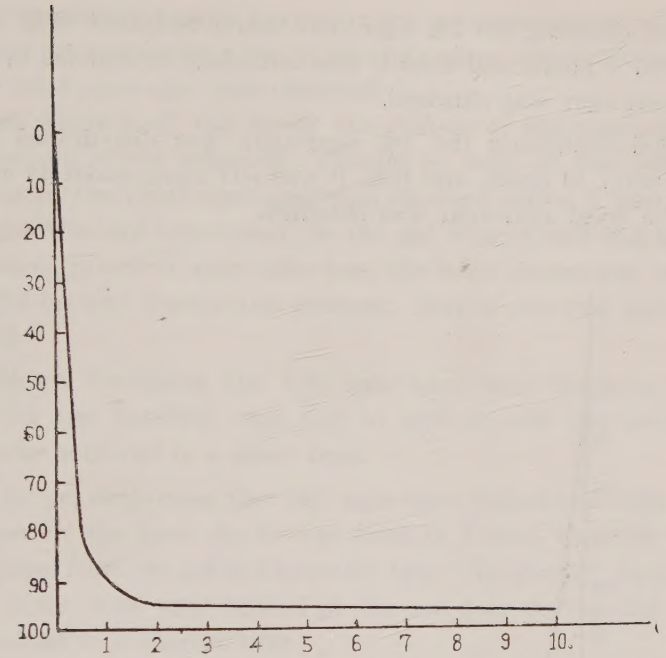

Fig. 2. Dehydration of the gel containing 2% agar-agar. (Thickness 0.5 cm.). Ordinate—dehydration ratio; Abscissa—hour.

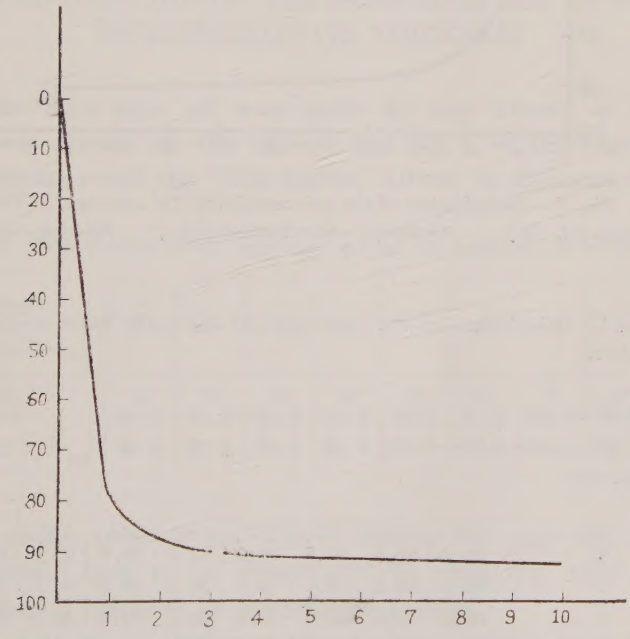

Fig. 3. Dehydration of the gel containing 3% agar-agar. (Thickness 0.5 cm.). Ordinate—dehydration ratio; Abscissa—hour.

The gel containg the 2% agar-agar was dehydrated 90% after 1 hour, and 96% after 4 hours, and then it was left alone 30 minutes in the open air, the dried agar-agar was obtained.

The gel containing the 3% agar-agar was dehydrated 90% after 4 hours, 93% after 10 hours, and then it was left alone about 45 minutes in the open air, the dried agar-agar was obtained.

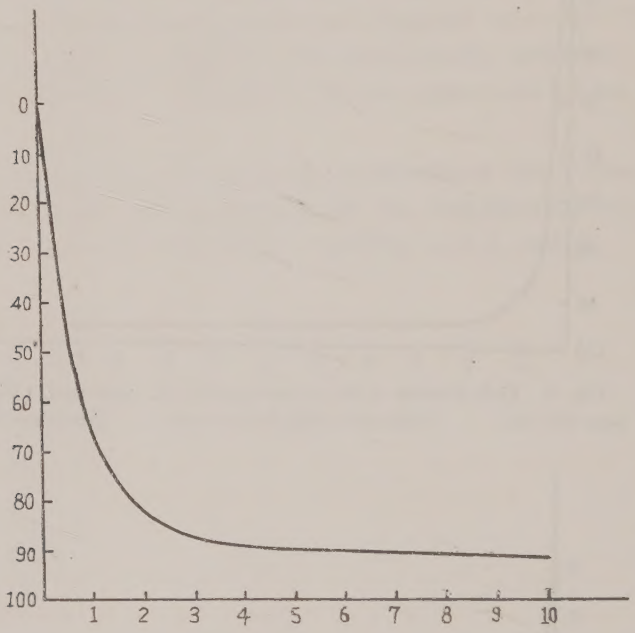

Fig. 4. Dehydration of the gel containing 4% agar-agar. (Thickness 0.5 cm.). Ordinate—dehydration ratio; Abscissa—hour.

Table 1. Dehydration of the agar-agar gel due to the difference of its concentrations.

Hour / Conc. of the agar-agar	0.5	1	2	3	4	5	6	8	10
%	%	%	%	%	%	%	%	%	%
1	96.0	96.5	96.5	98.0	98.0	98.0	98.0	98.0	98.0
2	80.0	90.0	93.0	94.0	96.0	96.0	96.5	97.0	97.5
3	60.0	80.0	88.0	89.0	90.0	91.0	92.0	92.5	93.0
4	47.0	64.0	83.0	87.0	89.0	90.0	91.0	92.0	92.5

The gel containing the 4% agar-agar was dehydrated 90% after 5 hours, and 92.5% after 10 hours, and after it was left alone about 45 minutes in the open air, the dried agar-agar was obtained.

As above mentioned, the lower the content of the agar-agar was, the more the dehydration was achieved. Though in case of the gel containing the 1% agar-agar, the dried agar-agar was obtained within 1 hour, the handling of the gel was not convenient, as the gel was so soft and brittle. The higher the concentration of agar-agar was, the more convenient the handling was, as the gel became harder and stronger. But it required more hours to be dehydrated.

Then the gel containing the 2% agar-agar was the most suitable for this purpose as the handling was not so difficult and the purpose of the dehydration was achieved in a short time.

When the gel containing the 2% agar-agar dehydrated 90% for 1 hour was left alone in the open air, it was dried in 1 hour, thus the dried agar-agar was obtained from the gel in 2 hours by this "Ton platte" method. When the hot air dryer was used instead of the out-door drying, the dried agar-agar was obtained in a shorter time.

2. DEHYDRATION OF THE AGAR-AGAR GEL BY THE INFLUENCE OF ITS THICKNESS

When the agar-agar gel was made 0.5 and 1.0 cm. in thickness, the dehydration was shown on the table 2, and Fig. 5. in this case the gel containing 2% agar-agar and the "Ton platte" 1.0 cm. in thickness were used.

Table 2. Dehydration of the agar-agar gel by the influence of its thickness

Hour / Thickness	0.1	1	2	3	4	5	6	8	10
cm	%	%	%	%	%	%	%	%	%
0.5	80.1	90.0	93.0	94.0	96.0	96.0	96.5	97.0	97.5
1.0	40.0	52.0	70.0	80.0	88.0	90.0	91.0	92.0	93.0

As the above table 2 and Fig. 5 shown the agar-agar gel 0.5 cm. in thickness required 1 hour to be dehydrated to 90%, but that of 1.0 cm. in thickness required 5 hours to be dehydrated to 90%.

The gel of 0.5 cm. in thickness was recommendable from the results of this experiment.

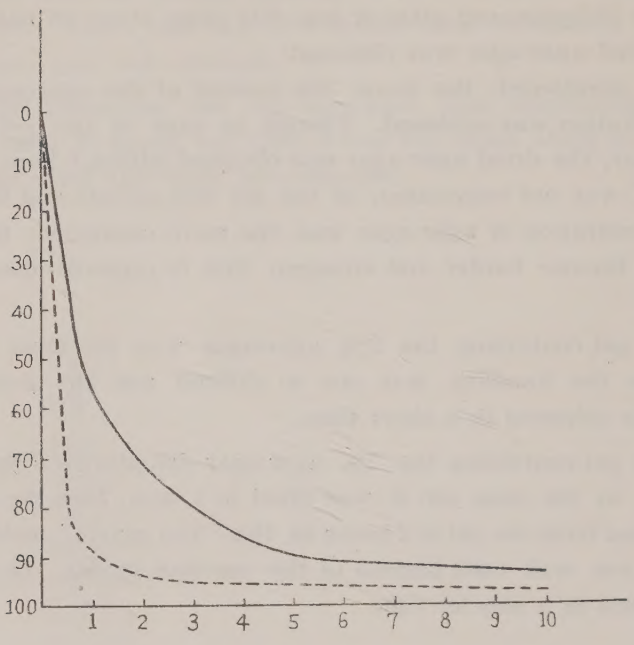

Fig. 5. Dehydration of the gel by the influence of its thickness.
(The content of agar-agar was 2%).
Ordinate—Dehydration ratio; Abscissa—Hour.
—The gel 1.0 cm. in thickness; ···The gel 0.5 cm. in thickness.

3. DEHYDRATION OF THE AGAR-AGAR GEL WHEN THE MOISTENED "TON PLATTE" WAS EXCHANGED FOR THE DRIED ONE

When the moistened "Ton platte" was exchanged for the dried one each 30 minutes, the results were shown on the table 3.

In this case the gel containing 2% agar-agar 0.5 and 1.0 cm. in thickness were used.

Table 3. Dehydration when the moistened "Ton platte" was exchanged for the dried one each 30 minutes.

A number of times of the exchange of the "Ton platte"	1	2	3	4
Dehydrated percentage of the gel 0.5 cm. in thickness	% 80.0	% 93.0	% 93.5	% 94.0
Dehydrated percentage of the gel 1.0 cm. in thickness	40.0	53.0	63.0	70.0

As shown on the table 3, it was a little effective on the gel, of 0.5 cm. in thickness, since it was dehydrated 93% after one time exchange.

But on the gel of 1.0 cm. in thickness it was not effective, since it was almost the same as the "Ton platte" was not exchanged.

4. DEHYDRATION OF THE AGAR-AGAR GEL BY THE INFLUENCE OF THE WEIGHT

In case of no weight and a weight of 1 kg., 3 kg., 5 kg., 10 kg. and 15 kg. on the "Ton platte", the dehydration was observed.

The results were shown on the table 4. In this cases the gel containing 2% agar-agar 0.5 cm. in thickness was used.

Table 4. Dehydration influenced by the weight.

Weight \ Hour	0.5	1	2	3	4
kg	%	%	%	%	%
none	75.0	90.0	92.0	94.0	96.0
1	80.0	90.0	93.0	94.0	96.0
3	77.0	91.0	93.0	94.0	96.0
5	80.0	92.0	93.0	94.0	96.0
10	80.0	92.0	93.0	94.0	96.0
15	82.0	92.0	93.0	94.0	96.0

As the above table shows it was a little effective after 30 minutes and 1 hour according to the weight, but this difference of dehydration was 2 or 3% and it was negligible value.

Thus there was no influence by the weights.

The dehydration was almost the same in case of no weight as in case of the greater weight. Then it was known that the dehydration was not caused by the pressure but due to the vacuum of the contact surface.

5. DEHYDRATION WHEN THE AGAR-AGAR AND THE "TON PLATTE" WERE PILED ONE ON ANOTHER

In this case the "Ton platte" 1.0 cm., 0.8 cm., and 0.5 cm. in thickness, and the gel containing 2% agar-agar 0.5 cm. in thickness were piled one on another. The results of dehydration were shown on the table 5, 6, and 7.

As seen on the table 5, 6, and 7, the dehydration was carried out all alike on each agar-agar gel. The gels placed on the upper side and the down side were dehydrated a little more than the others at the beginning. It seemed to be due to the fact that in case of the others the both surfaces were used.

The thickness of the "Ton platte" had a remarkable influence, namely,

Table 5. Dehydration when the "Ton platte" 1.0 cm. in thickness were used

Hour / Number of gel	0.5	1	2	3
1	% 83.7	% 91.3	% 91.8	% 94.0
2	75.6	87.9	91.4	94.0
3	68.9	88.8	91.5	93.9
4	77.0	91.1	91.1	93.9
5	82.5	91.9	91.9	94.0
Average	77.4	90.1	91.5	93.9

Table 6. Dehydration when the "Ton platte" 0.8 cm. in thickness were used,

Hour / Number of gel	0.5	1	2	3
1	% 70.4	% 86.5	% 90.6	% 93.5
2	65.0	88.6	89.9	93.1
3	61.2	80.0	90.0	92.0
4	64.4	81.1	90.0	92.8
5	66.7	86.0	91.4	93.3
Average	65.5	83.2	90.4	92.9

Table 7. Dehydration when the "Ton platte" 0.5 cm. in thickness were used.

Hour / Number of gel	0.5	1	2	3
1	% 56.9	% 75.0	% 84.2	% 88.2
2	50.0	73.4	84.5	88.8
3	53.7	73.1	85.4	89.8
4	55.2	74.0	85.1	90.0
5	57.4	80.5	86.1	91.1
Average	54.6	75.6	85.0	89.6

the "Ton platte" 1.0 cm. in thickness required 1 hour, 0.8 cm, in thickness required 2 hours, and 0.5 cm. in thickness required 3 hours to dehydrated the gel to 90%. Therefore, it was known that the dehydration increased in proportion to the thickness of the "Ton platte".

6. INGREDIENTS OF THE AGAR-AGAR PREPARED BY THIS "TON PLATTE" METHOD

The ingredients of the agar-agar prepared by this "Ton platte" method extracted from *Gelidium Amansii* LAMS. was compared with those of the agar-agar dried in air as it was, the results were shown on the table 8.

As shown on the table 8, the contents of the ash and the total nitrogen of the agar-agar prepared by this method showed a decrease as compared with the agar-agar dried in the air as it was.

The strength of the jelly of the agar-agar prepared by this method was very high.

The impurities in the agar-agar gel were removed with the water adsorbed, therefore the agar-agar was purified simultaneously with the dehydration.

Table 8. Ingredients of the agar-agar.

Ingredients / Procedure of dehydration	Moisture	Ash	Total nitrogen	Jelly strength
	%	%	%	g/cm²
Agar-agar dried in the air	22.5	3.89	1.52	405.0
Agar-agar dehydrated by this method	22.1	2.30	0.42	450.0

7. DEHYDATION BY THIS "TON PLATTE" METHOD WAS COMPARED WITH THE DEHYDRATION BY THE "BENTONITE" METHOD REPORTED ON THE PART 1.[1]

This "Ton platte" method was compared with the method reported on the part 1.[1] The results were shown on the table 9 and Fig. 6.

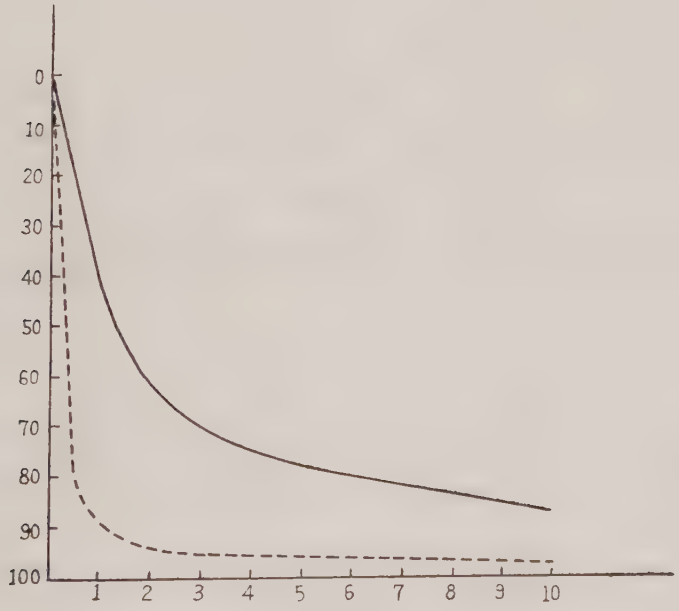

Fig. 6. Comparison of the "Ton platte" and the "Bentonite" method. (The gel containing 2% agar-agar and 0.5 cm. in thickness was used.) Ordinate—Dehydration ratio; Abscissa—Hour. —"Bentonite" method; ···"Ton platte" method.

Table 9. Comparison of the results taken by both the methods.

Method of dehydration \ Hour	0.5	1	2	3	4	5	6	8	10
"Ton platte"	% 80.0	% 90.0	% 93.0	% 94.0	% 96.0	% 96.0	% 96.5	% 97.0	% 97.5
"Bentonite"	—	42.0	60.0	—	75.0	—	80.0	84.0	87.0

As shown on the table 9, it required only 1 hour to dehydrate the gel to 90% by this "Ton platte" method, but it required 10 hours more to dehydrate it to the same degree by the "Bentonite" method.

Therefore the "Ton platte" method was superior to the "Bentonite" method.

In both methods the gel containing 2% agar-agar 0.5 cm. in thickness was used.

8. ABILITY OF THE ADSORPTION OF THE "TON PLATTE".

The moistened "Ton platte" was used repeatedly through drying.

It was adsorbed the soluble matters of the agar-agar gel e. g. the inorganic matters and the nitrogenous substances etc.

The capillary of the "Ton platte" is to be filled up with those soluble matters. But these soluble matters is to be washed out with hot water, since these matters are soluble in water.

The moistened "Ton platte" required 1 hour to be dried in hot air dryer, but when it was left alone in a room, it required 24 hours to be dried.

This "Ton platte" did not decrease its ability of adsorption after 30 times repeated use.

An equal quantity of water was adsorbed into the both upper and down side of the "Ton platte".

When the content of agar-agar and the surface area of the gel was constant, the absolute volume of adsorbed water into the "Ton platte" was almost the same on both gels 0.5 and 1.0 cm. in thickness as shown on the table 10 at the beginning.

Therefore the velocity of the adsorption of the "Ton platte" was not related to the thickness of the agar-agar gel.

And when the surface area and the thickness of the agar-agar gel were constant, and the concentration of agar-agar was different, the velocity of adsorption of the "Ton platte" was in reverse proportion to the concentration of the agar-agar as shown on the table 11.

Table 10. Absolute volume of adsorbed water into the "Ton platte". (Thickness of the gel was differnt.)

Thickness of the gel	Hour / Weight of the gel	0.5	1	2	3
cm	g	g	g	g	g
0.5	50.0	39.2	44.1	45.6	46.1
1.0	100.0	39.2	50.9	68.6	77.5

Table 11. Absolute volume of adsorbed water into the "Ton platte". (The concentration of the agar-agar was different.)

Concentration of the gel	Hour / Weight of the gel	0.5	1	2	3
%	g	g	g	g	g
1	50.0	47.1	47.3	47.3	48.0
2	50.0	39.2	44.1	45.6	46.1
3	50.0	29.4	39.2	43.2	43.7
4	50.0	23.0	31.4	40.7	42.6

9. DEHYDRATION BY THE INFLUENCE OF THE SECTION OF THE AGAR-AGAR GEL.

When the section of the agar-agar gel was not cut into a thin slice uniformly, the dehydration was considerably influenced as shown on the table 12 and Fig. 7.

Table 12. Influence of the section of the agar-agar gel.

Hour / Section	0.5	1	2	3	4
	%	%	%	%	%
Uniform	80.0	90.0	93.0	94.0	96.0
Not uniform	53.0	72.5	80.0	87.0	90.0

When the surface of the gel was not uniformly sliced, it required 4 hours to be dehydrated to 90%, but the gel of the uniform surface required only 1 hour.

When the surface of the gel was not uniformly sliced, the surfaces of the gel and the "Ton platte" were not stuck fast to, and did not form a vacuum.

In this case the gel containing 2% agar-agar 0.5 cm. in thickness was used.

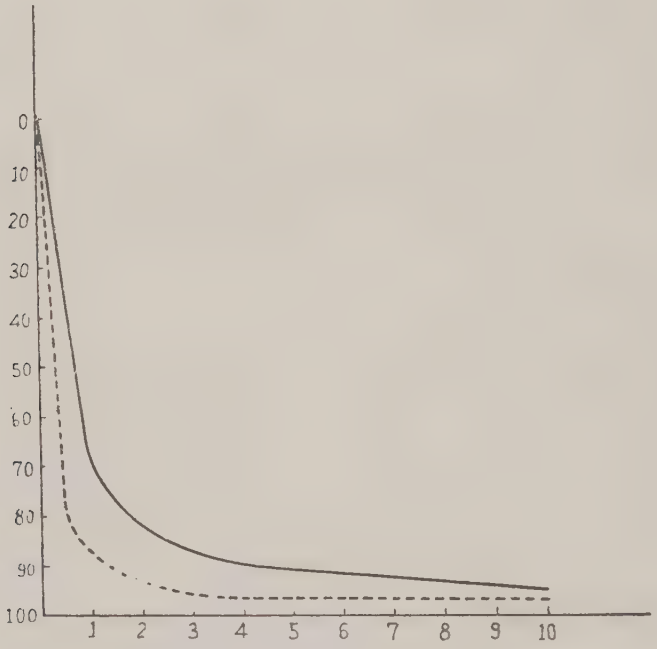

Fig. 7. Dehydration by the influence of the section of the agar-agar gel. (The gel containing 2% agar-agar and 0.5 cm. in thickness was used.) Ordinate—Dehydration ratio; Abscissa—Hour. —Not uniform surface; ···Uniform surface.

10. EMPIRICAL FORMULA OF THE RESIDUAL WATER IN THE AGAR-AGAR GEL.

When the agar-agar contained y_0 parts in 100 parts of the agar-agar gel, the water was contained $100-y_0$.

If y parts of the water was removed within x hour, for example, on the gel containing 4% agar-agar, it remined 49% of water after 30 minutes, 32% after 1 hour and so forth, becouse it exist 96% of water at the beginning of the dehydration. (x=o)

When it was plotted on the logarithmic paper, it showed almost straight

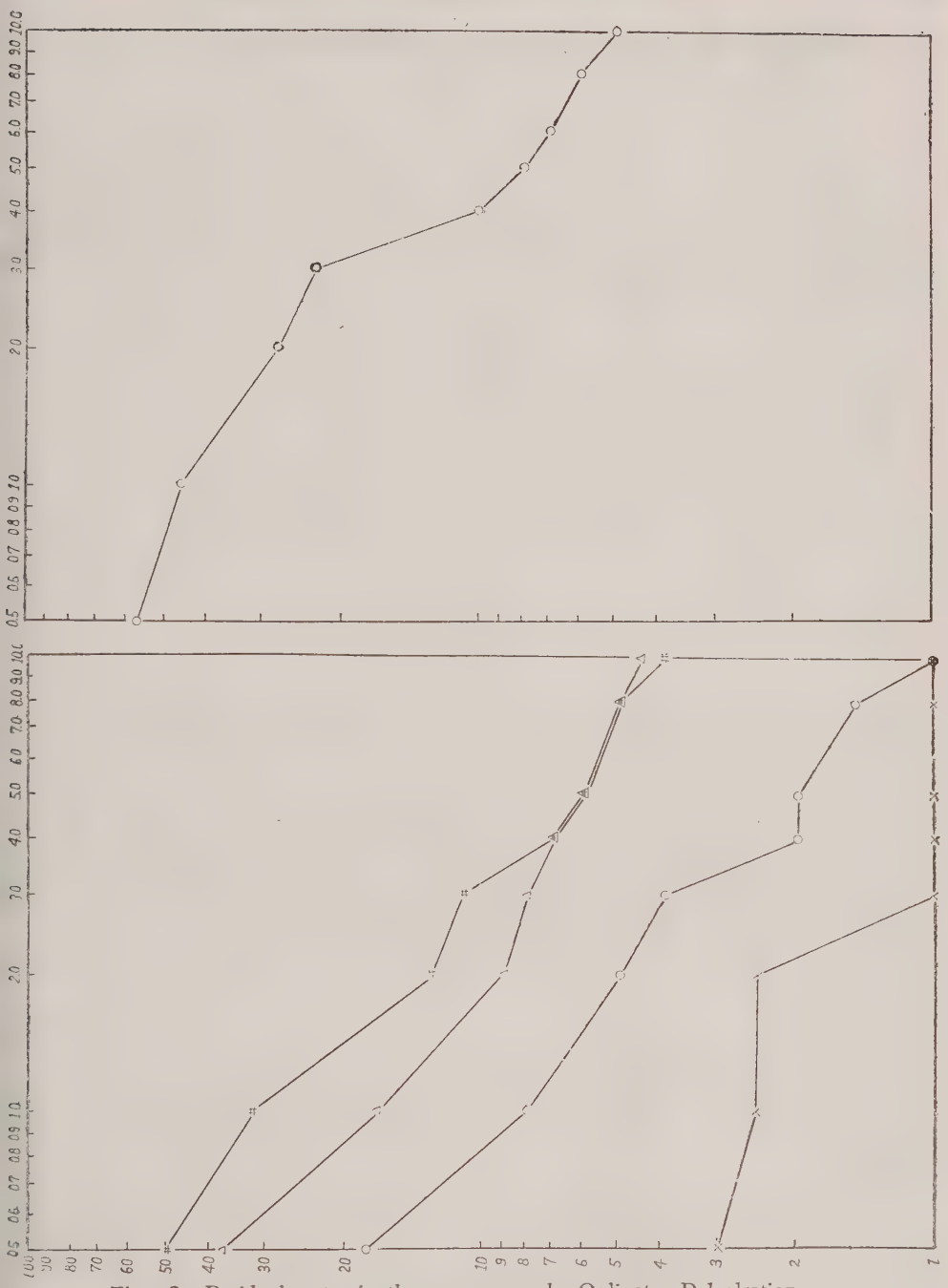

Fig. 8. Residual water in the agar-agar gel. Ordinate—Dehydration ratio; Abscissa—Hour

× — The gel containing 1% agar-agar 0.5 cm. in thickness.
○ — The gel containing 2% agar-agar 0.5 cm and 1.0 cm. (on the right side) in thickness.
△ — The gel containing 3% agar-agar 0.5 cm. in thickness.
— The gel containing 4% agar-agar 0.5 cm. in thickness.

line as shown on the Fig. 8, namely, when the residual water was assumed as Z %, the relation was represented as follows:-

$$\log_{10} Z = a \log_{10} x + b$$

or

$$Z = BX^A$$

The roughly estimated value of a and b was shown on the table 13, a was almost constant and b increased in proportion to the agar-agar content. (The gel containing 1% agar-agar was not calculated, as the results were not convenient to calculate.)

Table 13. Roughly estimated value of a and b.

Thickness of the gel	0.5 cm.				1.0 cm.
Conc. of the gel (%)	1	2	3	4	2
a	—	−0.869	−0.838	−0.886	−0.951
b	—	0.929	1.285	1.462	1.624

Résumé

1. This "Ton platte" method was so excellent that the dried agar-agar was obtained in a short time as compared with the other methods.

2. When the agar-agar gel 0.5 cm. in thickness was used, the lower the content of the agar-agar was, the more the dehydration was achieved. But the gel containing 2% agar-agar was the most suitable, as the handling of the gel was not so difficult and the dehydration was achieved in a short time, then the dried agar-agar was obtained within 2 hours.

3. The thickness of the agar-agar gel was the most suitable at 0.5 cm. in this experiment.

4. When the moistened "Ton platte" was exchanged for dried one, the dehydration was not influenced considerably.

5. The weight on the plate has not an absolute influence. Therefore the dehydration was not due to the pressure but to the adsorption of the "Ton platte".

6. When the agar-agar gels and the "Ton platte" was piled one on another, the dehydration was smoothly achieved, but the thickness of the "Ton platte" had a remarkable influence.

7. The agar-agar gel was purified simultaneously with dehydration, since the contents of the ash and the total nitrogen were decreased, and the jelly strength was very high.

8. This "Ton platte" method was superior to the "Bentonite" method reported on the part 1.

9. The moistened "Ton platte" was dried within 1 hour through the hot air dryer, and repeatedly used.

10. When the section of the agar-agar gel was not uniformly sliced, the dehydration required many hours.

11. It was considered that the adsorption was caused due to the vacuum on the tightly contacted surfaces of the agar-agar gel and the "Ton platte", and the adsorbed water was dispersed into the "Ton platte", thus the purpose of the dehydration was satisfactorily achieved.

12. This "Ton platte" method was economical as compared with the other methods to which many mechanical processes are necessary.

13. This "Ton platte" method can be applied throughout the year all over the world, since it was not affected by the influence of the weather.

14. The velocity of the adsorption into the "Ton platte" was in reverse proportion to the concentration, and not related to the thickness of the agar-agar gel.

15. The determination of agar-agar content in the sea weed (raw materials of agar-agar) can be quantitatively detrmined easily in a short time by this adsorption method.

16. In this adsorption method, other porous plates, such as gypsum, vinyl and pulp can be used.

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Journal of the Tokyo University of Fisheries Vol. 38, No. 3, 1952.

BIOCHEMICAL STUDIES ON THE VITAMIN A IN FISH VISCERA.
1. THE FAT AND VITAMIN A CONTENT OF A CERTAIN MACKEREL IN PACIFIC COAST OF JAPAN.

Toyoki ONO and Tetsuo SATO.

(Received Jan. 15, 1952)

The variations of the vitamin A content of fish liver are caused in such biological conditions as season and locality of catching, age and sex of fish. Several studies concerning in these matters above mentioned have hitherto been made on those fishes, cod, shark, bonito, tuna etc[1,2,3,4,5].

Through these experiments, the facts were pointed out that the vitamin A content of fish liver oil is maximum at the time of maturation and drops off quite rapidly after spawning off, and that the vitamin A potency in a large fish is more higher than a small one under a certain season at a given locality. Generally the theory of making the maximum vitamin A content in a certain fish liver during their maturation, is introduced in a reason that at that time the oil content of liver indicates a minimal value, due to accumulating the bulk of neutral fats in fish body as depot fat, and is consequently condensed the vitamin A in liver oil with a highest value.

If such a theory is biologically correct, it is interest to ascertain whether the absolute amount of vitamin A in liver for all fish are changed throughout the year or not. Although several studies have been made by this time, the biochemistry of vitamin A in fish viscera standing on its maturation are not still established. We attempted to investigate biochemically the vitamin A in liver, and the relations between the vitamin A content in viscera and the fat content in fish body.

Experimental

Mackerel distributed in Japanese coast waters, is classified to two species of Ma-saba, *Scomber japonicus* HOUTTUYN and Goma-saba, *Scomber apeinocephalus* (BLEEKER). The fish (Ma-saba) used in this study were caught in off Izu-Oshima, of length 30~35 cm. and weight 500~600 gm. Three males

and females were used on each experiment, but one fish was necessarily used.

The samples were brought to the laboratory immediately after landing in market. In a strictly fresh condition, they were weighed and lengthened, and then fish body was separated to three parts, head, whole viscera and edible part. The whole viscera were removed to liver, spleen, heart, stomach, intestine, pyloric caeca, sexual gland and remaining viscera. The edible parts were divided into four sections as Figure 1.

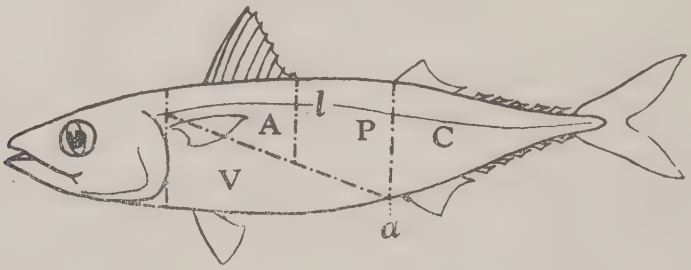

Fig. 1. Showing the Division of the Edible Part into four Parts which Moisture and Fat Content were analysed.
A. — Anterior dorso-lateral part of trunk.
P. — Posterior dorso-lateral part of trunk.
C. — Caudal part (Caudal part based mainly on the posterior part of second dorsal fin).
V. — Ventral part.
a. — anus. l. — lateral line.

Moisture and fat content. — An aliqot of approximately 1~3 gm. of homogenized sample was ground with 10 gm. of anhydrous sodium sulphate and quantatively transferred to the weighing bottle which was heated in electric oven at 105°C, for 3 hours The moisture content of sample was calculated from its loss of weight.

The residue remained in the weighing bottle was transferred to the thimble which was then insert in the Soxhlet's extractor. The fat content was calculated from the ether extracts.

The vitamin A content. — 0.5~1.0 gm. of liver or other viscera was ground with 7 gm. of anhydrous sodium sulphate. The ground sample was extracted with 5 cc. of chloroform and after two minutes filtered the chloroform solution through the dried filterpaper. Translated 0.1~0.5 cc. of filtrate to a test tube, in which diluted the solution with solvent to 100~200 times in accordance with the concentration of vitamin A. 0.2 cc. of the diluted solution was taken in a tintometer cell, and blown into it 2 cc of 30% antimony trichloride in chloroform. The intensity of the resulting blue color was measured at exactly thirty seconds after the addition of reagent. In addition

to this blue color, however, yellow color or often red color appears as a result of the color reaction, from which are obtained the corrected results using a tintometer.

As a result of the less stability, the chromophor, the blue color for vitamin A fades rapidly after its development. The determination of vitamin A by the Carr-Price reaction, therefore, must be carried on under the most attentive procedures. For a reason of removing such a disadvantage, Sobel and Werbin[6] has been proposed the use of activated glycerol dichlorhydrin as a reagent for the colorimetric estimation of vitamin A. But this new method has yet a fault that it demands a long time for determining on account of the low activity of the reagent.

In view of this fact, it is shown that the colorimetric (chemical) methods have much convenience to measure by the simple process and more common instrument, but less precise compared with the photometric (physical) methods. In spite of pointing out a disadvantage of former method, we must determined the vitamin A potency by former method immediately in landing place, on account of possessing the freshness of sample and less dropping the vitamin A potency.

The results obtained from the determination by both chemical and physical methods are as follows.

Table 1. Comparison of Chemical and Physical Methods for Vitamin A Content in Shark Liver Oils

Estimation method	Shark liver oils		
	Sample 1	Sample 2	Sample 3
	I.U.	I.U.	I.U.
Photometric-1.	27,500	53,300	148,600
Colorimetric-1.	27,800	57,800	100,400
Colorimetric-2.	23,600	54,000	101,500
Colorimetric-3.	30,400	60,800	76,000

Photometric-1. ····· Beckman quartz spectrophotometer
Colorimetric-1. ····· Tintometer; Colorimetric-2,-3 ····· Simple colorimeter (Oshima's aparatus)

Table I showed that the difference between both methods less reprensented in case of the liver oil of lower vitamin A potency, except the liver oil of 100,000 I. U. or more (I. U. represents the International Unit)

Therefore, the colorimetric method will be able to employed for the vitamin A determination of mackerel liver oil which vitamin A potency is low in general than 100,000 I. U.

Results

I. *Seasonal variations in the weight and length of body and viscera*

(a). Total weight and length of body.

In a certain time after the spawning —— from August to December the weight and length of fish body decreased as compared with other seasons in all males and females, which fact is as same as the weight of sexual gland.

On the contrary, the weight-length relationship —— to express the fatness of fish body we employed a factor (f), f was calculated according to the formula $f = \frac{W}{l_3} \times 1000$, where W is the total weight in gm. and l is the length of fish body in cm. was independent of spawning; the minimum of f appeared in April.

Influence in sex: Weight and length were more excellent in female than male by months and for the entire year. However, the values of f (the weight-length factor) were more or less low in female than male (Table 2, 3; Figure 2).

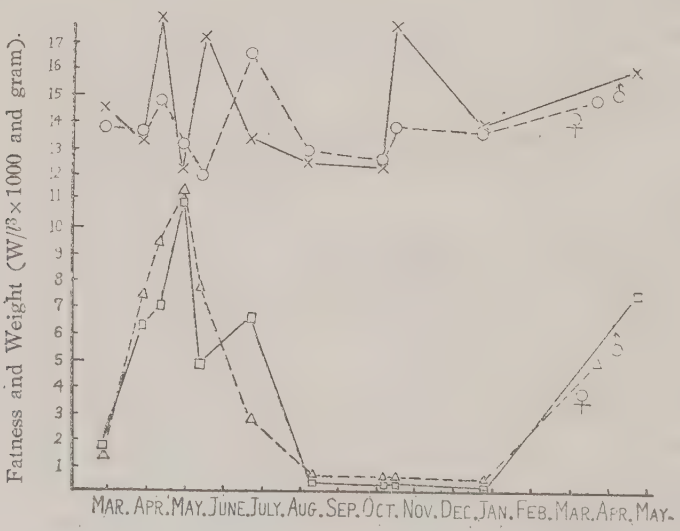

Fig. 2. Change in the Fatness and Sexual Gland.
—×— Fatness of male.
···○··· " " female.
—□— Sexual gland weight of male.
···△··· " " " " female.

(b). Viscera.

As regards to the seasonal variations in the weight of viscera, all other

viscera except sexual-gland, pyloric caeca and liver gave less variation. However, the amounts of contents (food) in stomach gives a considerable effect to the weight of viscera. As shown in table 2, 3, therefore, there was much difference between the weight of stomach contained and removed the contents (food); it will be emphasized in the ratio in stomach-weight and body-weight.

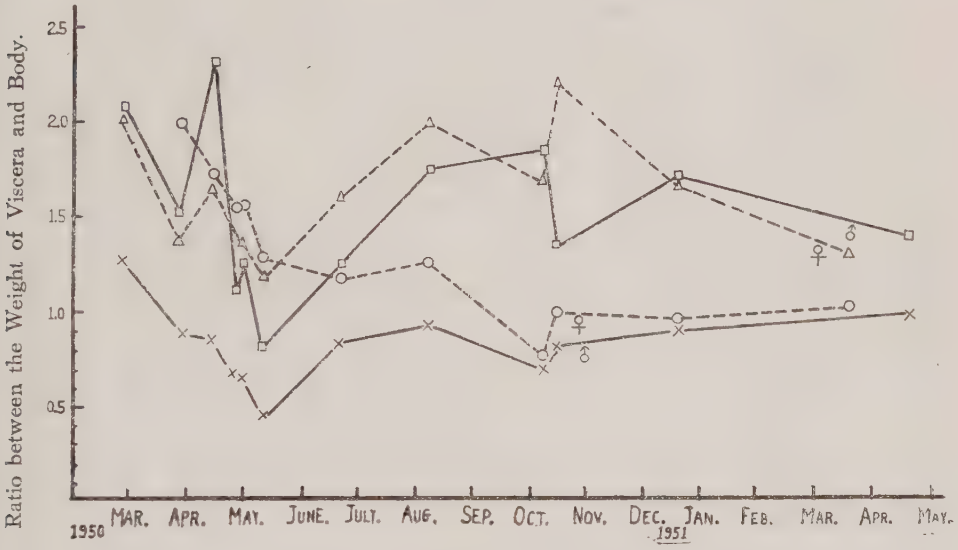

Fig. 3. Change in the Weight of Liver and Pyloric caeca.
—×— Liver of male.
···○··· 〃 〃 female.
—□— Pyloric caeca of male.
···△··· 〃 〃 〃 female.

Sexual gland increased the weight during the maturation, and it was observed to reach the maximum value in a certain time between April and May (Table 2, 3; Figure 3).

The sexual gland-weight and vitamin A potency gave the highest value at the late stage in maturation, while in that time both liver and pyloric caeca were in the lower or lowest value.

II. *Seasonal variations in the fat content of edible parts and viscera.*

(a) Edible parts

As shown in table 4 (male) and 5 (female), each separated edible part (Figure 1) showed a gradual increase in the fat content and reached its value to the maximum at a stage before the spawning, but after spawning it decreased rapidly as well as the weight of fish body.

Table 2. Variations in the Biological Analysis of Mackerel.

Male

Sample number	Number of fish	Date of catching	Length cm. (l)	Weight gm. (W)	Fatness $W/l^3\times1000$		Whole viscera		Liver		Spleen		Heart		Intestine		Pyloric caeca		Sexual gland		Stomach a		Stomach b	
					A	B	Weight (gm)	Ratio w/W (%)	w (gm)	w/W (%)	w (gm)	w/W (%)	w (gm)	w/W (%)	w (gm)	w/W (%)	w (gm)	w/W (%)	w (gm)	w/W (%)	w (gm)	w/W (%)	w (gm)	w/W (%)	w (gm)	w/W (%)
1	2	(1950) 2.28	35.0	623.0	14.5	13.0	63.7	10.20	8.0	1.28	0.6	0.10	2.2	0.35	5.1	0.82	13.0	2.08	12.2	1.96	22.5	3.60	—	—
3	5	3.29	35.9	614.0	13.2	11.7	75.0	12.20	5.5	0.89	0.9	0.15	1.6	0.26	5.2	0.85	9.3	1.52	37.0	6.03	15.5	2.53	—	—
5	2	4.13	31.0	561.0	18.8	15.2	107.0	19.10	4.8	0.85	0.5	0.11	1.9	0.35	6.9	1.23	13.1	2.34	39.4	7.00	40.4	7.20	23.2	4.14
7	2	4.24	35.2	563.0	12.9	11.0	85.0	15.10	3.8	0.67	0.8	0.14	2.1	0.37	3.0	0.53	6.2	1.10	61.1	10.85	13.7	2.44	5.0	0.87
9	4	4.30	35.5	536.0	12.0	10.2	75.5	14.10	3.3	0.65	0.7	0.13	—	—	3.5	0.65	6.8	1.27	49.6	9.25	12.0	2.24	6.0	1.12
11	2	5.11	34.1	707.0	17.9	15.9	78.0	11.00	3.1	0.44	—	—	—	—	—	—	5.7	0.81	33.2	4.70	25.5	3.61	6.8	0.96
13	3	6.20	28.9	322.0	13.3	11.1	54.0	16.80	2.7	0.84	0.3	0.08	1.3	0.41	5.0	1.55	4.0	1.25	24.7	7.67	10.0	3.10	4.2	1.32
15	4	8.8	33.2	488.0	12.6	11.6	65.4	13.40	4.5	0.92	0.7	0.14	1.6	0.33	9.3	1.91	8.6	1.76	1.7	0.35	29.6	6.07	5.0	1.25
17	3	10.9	29.4	320.0	12.6	11.2	35.5	11.10	2.2	0.69	—	—	—	—	6.0	1.88	5.9	1.84	2.2	0.69	11.2	3.50	3.9	1.22
19	2	10.16	30.5	515.0	18.2	16.5	46.0	8.90	4.2	0.81	0.4	0.08	1.5	0.29	4.8	0.93	7.0	1.36	3.5	0.68	19.7	3.82	5.2	1.01
21	5	12.20	32.9	488.0	13.7	11.3	85.4	17.50	4.4	0.90	—	—	2.3	0.47	4.7	0.96	8.4	1.72	1.6	0.33	58.4	11.94	8.0	1.64
23	3	(1951) 4.24	35.0	713.0	16.6	14.6	86.2	12.09	6.2	0.87	1.4	0.20	2.6	0.37	5.6	0.79	0.0	1.40	52.8	7.41	6.8	0.95	4.8	0.67
25	1	4.28	35.2	615.0	11.1	12.0	92.4	15.02	4.0	0.65	1.5	0.25	1.9	0.31	6.2	1.01	5.4	0.88	63.1	10.26	6.2	1.01	5.0	0.80
Average	2.9	—	34.5	616.5	15.1	13.1	73.0	13.59	4.8	0.78	0.8	0.14	1.9	0.35	5.4	1.09	8.0	1.49	20.5	5.17	24.0	4.00	7.0	1.37

A……Case of containing whole viscera. B……Case of without whole viscera.

a ……Case of containing contents (food). b……Case of without contents.

Table 3. Variations in the Biological Analysis of Mackerel

Female

Sample number	Number of fish	Date of catching	Length cm. (l)	Weight gm. (W)	Fatness $W/l^3\times1000$ A	Fatness $W/l^3\times1000$ B	Whole viscera Weight (gm)	Whole viscera Ratio w/W (%)	Liver w (gm)	Liver w/W (%)	Spleen w (gm)	Spleen w/W (%)	Heart w (gm)	Heart w/W (%)	Intestine w (gm)	Intestine w/W (%)	Pyloric caeca w (gm)	Pyloric caeca w/W (%)	Sexual gland w (gm)	Sexual gland w/W (%)	Stomach a w (gm)	Stomach a w/W (%)	Stomach b w (gm)	Stomach b w/W (%)
2	4	(1950) 3.28	35.0	594.0	13.8	12.4	62.1	10.50	7.5	1.26	0.7	0.12	3.6	0.61	5.1	0.86	12.2	2.03	11.5	1.94	21.5	3.60	6.0	1.01
4	2	3.29	36.3	651.0	13.6	11.7	93.1	14.30	13.0	2.00	0.7	0.11	1.6	0.25	4.7	0.72	9.0	1.38	47.7	7.32	16.4	2.52	5.8	0.90
6	5	4.13	33.5	559.0	14.9	11.9	109.9	19.70	9.7	1.74	0.6	0.11	1.6	0.28	6.1	1.03	9.3	1.66	53.0	9.47	17.7	3.17	6.3	1.13
8	2	4.24	37.3	558.0	10.7	9.6	60.3	10.80	8.9	1.57	0.7	0.13	1.8	0.32	3.9	0.69	7.6	1.36	29.7	5.32	8.1	1.44	5.3	0.95
10	3	4.30	35.5	558.0	13.2	10.9	99.0	16.80	0.3	1.58	1.0	0.17	—	—	3.5	0.59	8.0	1.36	67.2	11.42	7.5	1.27	4.5	0.76
12	2	5.11	35.5	520.0	11.8	9.9	75.3	14.50	6.7	1.29	—	—	—	—	—	—	6.2	1.19	41.2	7.90	12.1	2.34	5.3	1.02
14	1	6.20	33.8	640.0	16.6	14.5	78.5	12.30	7.6	1.19	0.6	0.09	2.0	0.36	7.7	1.20	10.3	1.61	17.3	2.70	26.8	4.19	7.6	1.19
16	3	8.8	32.8	456.0	12.9	11.5	50.8	11.10	5.8	1.27	0.9	0.20	1.1	0.22	9.4	2.30	9.1	2.08	2.4	0.53	17.9	3.93	6.8	1.49
18	3	10.9	29.6	326.0	12.6	11.0	41.0	12.60	2.5	0.77	—	—	—	—	3.8	1.17	5.5	1.68	2.8	0.86	20.5	6.29	3.7	1.18
20	4	10.16	30.0	375.0	13.9	12.4	39.7	10.10	5.7	1.52	0.3	0.08	1.0	0.26	7.0	1.86	8.3	2.22	3.7	0.98	10.3	2.76	4.8	1.28
22	2	12.20	32.7	460.0	13.6	11.4	63.1	13.70	4.4	0.96	—	—	2.1	0.45	7.4	1.61	7.6	1.65	2.9	0.63	45.4	9.87	7.0	1.52
24[a]	1	(1951) 3.20	36.1	660.0	14.5	11.9	98.6	14.90	6.8	1.03	0.5	0.08	2.0	0.30	5.8	0.88	8.7	1.31	33.7	5.11	24.1	3.82	5.6	0.85
24[b]	3	3.20	37.0	791.0	15.6	13.9	85.3	10.80	12.5	1.57	0.9	0.11	2.7	0.34	4.3	0.61	12.4	1.57	23.2	2.93	12.2	1.53	5.0	0.69
Average	2.7	—	34.2	552.1	13.7	11.8	73.6	13.23	7.7	1.37	0.6	0.12	2.0	0.34	5.1	1.13	3.1	1.63	25.9	4.40	18.5	3.60	5.7	1.08

A. Case of containing whole viscera. B. Case of without whole viscera.

a. Case of containing contents (food). b. Case of without contents.

In the four sections, the fat content was high in next order —— Caudal-, Posterior dorso-lateral-, Anterior dorso-lateral-, and Ventral-part, and the Ventral-part had the highest value (average in year 24.7%) while the lowest value in the Caudal-part (average in year 4.2%) (Table 4, 5). The increase and decrease in the fat content of body, appeared during the maturation or spawning, therefore, are almost taken place in the Ventral-part (Figure 4).

(b) Viscera

In regard to the seasonal variation in the fat content of whole viscera, it was almost no variable except liver through a year. But in female was shown a few much amount of fat content than male on an average in year (Figure 5).

The fat content of liver was some influenced in the maturation or the spawning of fish, and a similar tendency was reprensented in pyloric caeca and the other viscera (Table 4, 5).

Therefore, the variations in the fat content of mackerel viscera will be probably due to the fish individuality.

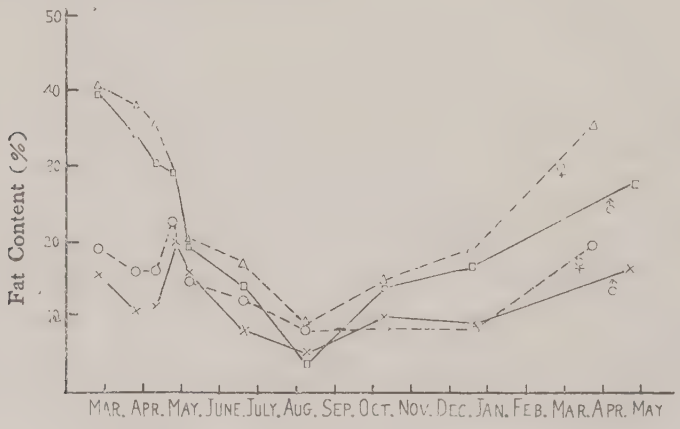

Fig. 4. Fat Content of Edible Part
—×— Whole edible part in male
···○··· 〃 〃 〃 〃 female
—□— Ventral part in male
···△··· 〃 〃 〃 female

III. *The vitamin A content of liver and liver oil.*

(a) The vitamin A content of liver.

The vitamin A content of liver had more considerable seasonal variation than the fat content, especially it was given exceedingly in before and after the spawning (Table 6); namely, the vitamin A in that time contained only 38 I. U. per gm. of liver, one by two hundredth of the highest value. It

is evident to be rapidly occurred such a change by the great physiological function consuming her entire energies to the spawning. It was occurred also for male such phenomenon as above mentioned, in which took place the sexual action of male; namely, the lowest value of the vitamin A content of male liver was only one by four hundredth of the highest value, the former was only 360 I. U. per gm. against 12,600 I. U. in the later.

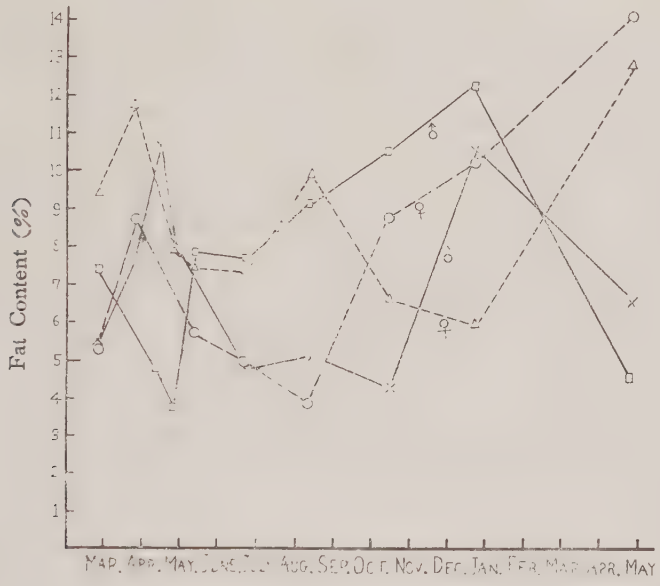

Fig. 5. Fat Content of Liver and Pyloric caeca
—×— Male liver
···○··· Female 〃
—□— Male pyloric caeca
···△··· Female 〃 〃

(b) The vitamin A potency of liver oil.

The vitamin A potency of liver oil was calculated from the following formula: $vo=\frac{L\times vl}{L\times o\times 0.01}$, where vo is the vitamin A content per gm. of liver oil in I. U., vl the vitamin A content per gm. of liver in I. U., L the weight of whole liver in gm., and o the oil content of liver in percentage.

As shown in Table 6, the sexual action in male and female gave an influence in the vitamin A potency of liver oil as well as liver tissue.

There was a great difference between the vitamin A potency of male- and female-liver oil; the average value of the former was approximately

Table 4. Variations in the Fat Content of the Edible Part and Viscera

Male

Sample number	Date of catching	Fat content of edible part (%)					Fat content of viscera (%)							
		I	II	III	IV	V	Whole viscera	Liver	Spleen	Heart	Intestine	Pyloric caeca	Stomach	Sexual gland
1	(1950) February, 28	16.43	8.05	12.73	2.13	39.90	—	5.52	—	6.65	9.66	7.44	—	1.15
3	March, 29	10.92	9.55	7.05	3.54	34.31	2.04	7.80	1.85	1.56	1.84	—	—	1.26
5	April, 13	11.70	9.51	8.09	2.88	30.44	3.43	10.66	1.73	2.64	2.63	3.82	4.67	1.90
7	April, 24	16.81	12.43	13.42	3.03	29.05	3.65	8.05	—	1.45	3.51	2.23	2.73	3.84
9	April, 30	19.33	—	5.83	4.01	28.83	6.08	7.84	3.84	—	2.25	3.74	5.54	1.05
11	May, 11	15.85	12.00	6.18	—	8.55	7.11	7.60	—	—	4.75	7.90	10.05	6.65
13	June, 20	8.30	6.68	4.50	2.57	14.50	5.35	4.92	—	—	3.85	7.75	5.57	2.10
15	August, 8	5.18	2.00	1.29	1.18	4.08	4.92	5.23	0.91	1.58	2.45	9.13	3.88	4.13
17	October, 9	10.15	9.35	12.20	3.56	14.06	8.24	11.67	—	—	6.43	10.54	4.51	10.15
19	October, 16	10.05	14.00	6.65	5.05	11.86	5.72	4.36	—	—	7.15	5.37	4.29	8.20
21	December, 20	9.34	15.63	5.57	4.93	16.91	7.59	10.45	—	2.24	6.24	12.26	4.03	4.70
23	(1951) April, 24	16.92	18.12	19.68	15.40	27.93	5.53	6.55	1.71	5.33	2.85	4.56	2.32	5.73
25	April, 28	—	—	—	—	—	2.59	6.75	1.50	2.58	3.51	3.70	2.30	2.18
Average		12.58	10.66	8.60	4.39	22.54	5.16	7.50	1.94	3.50	4.40	6.54	6.44	4.09

I ……Whole edible part.
II ……Anterior dorso-lateral part of trunk
III……Posterior dorso-lateral part of trunk
IV……Caudal part
V……Ventral part

Table 5. Variations in the Fat Content of the Edible Part and Viscera

Female

Sample number	Date of catching	Fat content of edible part (%)					Fat content of viscera (%)							
		I	II	III	IV	V	Whole viscera	Liver	Spleen	Heart	Intestine	Pyloric caeca	Stomach	Sexual gland
2	(1950) February, 28	19.50	38.20	16.40	—	40.20	8.50	5.33	3.50	2.63	10.71	9.40	3.80	8.55
4	March, 29	16.47	14.32	12.82	—	38.70	5.21	8.72	0.18	1.58	3.46	11.72	4.00	3.54
6	April, 13	16.92	7.91	13.19	—	36.28	5.37	6.36	0·54	2.90	—	5.68	4.90	5.33
8	April, 24	—	3.00	2.44	—	—	5.64	6.50	—	—	3.24	4.21	4.15	4.22
10	April, 30	23.51	—	20.70	—	30.00	6.40	5.44	—	—	—	7.88	3.08	6.56
12	May, 11	15.00	8.73	11.40	—	19.42	6.37	5.69	—	—	4.71	7.47	4.81	6.63
14	June, 20	13.78	12.70	9.10	8.77	17.40	3.14	5.00	3.23	—	1.48	7.32	2.33	1.57
16	August, 8	8.48	8.70	4.82	4.56	8.53	4.66	3.81	—	3.13	2.24	9.77	2.38	3.90
18	October, 9	9.03	17.85	5.20	4.00	14.58	10.67	13.72	—	—	11.66	13.20	7.67	5.60
20	October, 16	8.85	8.29	5.15	4.08	8.03	5.56	8.72	—	—	3.04	6.05	3.34	7.17
22	December, 20	8.70	11.90	5.20	3.60	19.50	6.30	10.30	—	0.50	3.10	6.60	3.50	18.60
24 a	(1951) March, 20	12.46	7.54	8.26	5.22	26.00	7.90	5.86	—	2.31	4.33	11.70	9.62	7.93
24 b	March, 20	28.35	28.65	25.00	25.60	45.70	10.90	13.90	4.87	3.30	11.40	23.20	5.00	5.18
Average		15.09	14.00	10.74	5.04	25.78	6.66	7.61	2.45	2.33	5.40	9.55	4.51	6.53

I ……Whole edible part.
II……Anterior dorso-lateral part of trunk
III……Posterior dorso-lateral part of trunk
IV……Caudal part
V……Ventral part

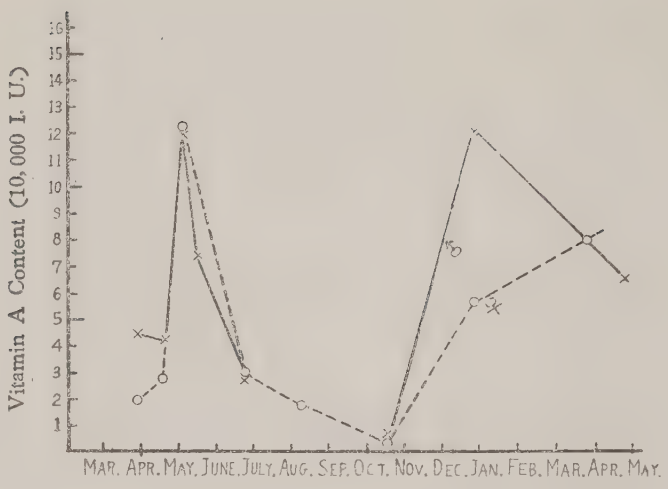

Fig. 6. Vitamin A Content of Mackerel Liver Oil
(International Unit per Gram)
—×— Male
···○··· Female

Table 6. The Vitamin A Potency of the Liver of Mackerel.

Date of catching	Male				Female			
	Weight of whole liver (Average, gm.)	Vitamin A content (I.U.)			Weight of whole liver (Average, gm.	Vitamin A content (I.U.)		
		In whole liver	In 1gm. liver	In 1gm. liver oil		In whole liver	In 1gm. liver	In 1gm. liver oil
1950								
March, 29	5.5	19,646	3,572	45,721	13.0	23,218	1,786	20,527
April, 13	4.8	18,240	3,800	35,849	9.7	16,296	1,680	26,250
April, 24	3.8	12,996	3,420	42,750	8.9	52,688	5,920	22,769
April, 30	3.3	31,350	9,500	121,800	9.3	60,246	6,480	120,000
May, 11	3.1	17,360	5,600	73,700	6.7	—	—	—
June, 20	2.7	5,043	1,025	28,333	7.6	13,087	1,722	29,186
August, 8	4.5	—	—	—	5.8	3,898	672	17,684
October, 9	2.2	5,322	2,419	20,853	2.5	1,230	492	3,606
October, 16	4.2	1,512	360	8,182	5.7	217	38	435
December, 20	4.4	55,698	12,654	121,769	4.4	24,966	5,674	55,087
1951								
March, 20		—	—	—	9.7	46,430	5,636	83,850
April, 24	4.0	27,094	4,370	66,718				
Average	4.8	19,400	4,700	56,600	7.7	28,100	3,300	14,900

66,000 I. U. per gm., while the one of the later gave 15,000 I. U. per gm; the ratio of both potency was 3:1 (Figure 6).

However, the individuality of fish is an important factor for the determination of the vitamin A potency in liver oil. In order to satisfy the result, therefore, it is need to use some number of sample.

Summary

A preliminary observation was carried on the biochemistry of vitamin A which concerned with the increase and decrease of the vitamin A potency of viscera and the relation between the fat content and vitamin A potency. The data was given for a certain mackerel cauted in the Pacific coast of Japan.

1. The fatness factor (*f*), the weight-length relationship did not represented a characteristic variation through a year, and there is no correlation between the factor and vitamin A potency. The weight of liver at a certain season (between May and June) decreased rapidly and then increased gradually, while the pyloric caeca weight indicated also a rapid decrease as well as liver. However, in case of the pyloric caeca, the increase in weight was rapidly occured in male and female. In this time, the sexual gland reached to the highest value in weight, and after the spawning it dropped rapidly and its shrink was continued until the late in December when the mackerel begin to maturation.

2. The change in the vitamin A content of liver oil was taken place in some mode as the sexual gland, but the vitamin A content increased rapidly at the late in October when the sexual gland was still shrink.

3. It is evident that the fat content of the edible part, especially the Ventral-part was very much influenced by the maturation and spawning, and the similar results were obtained in liver except the other viscera. However, such a change in the liver fat is little compared with the liver oil of the lean fish like shark and cod which fat metabolism is almost occurred in liver.

The vitamin A content of liver or the vitamin A potency of liver oil gave the lowest value at a certain time in August October when appeared the lowest fat content of liver.

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A POPULATION STUDY ON THE FISH, *TAIUS TUMIFRONS* OF THE TOSA BAY

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(Received Jan. 15, 1952)

Population studies of the fish, *Taius tumifrons* (T. & S.) which supplies an important fishery of Japan, have been of late carried out by such many investigators as AIKAWA and his three coworkers[1,2], KANDA[5], KAWAKAMI and MATSUI[6], MIYOSHI[7], MURAYAMA[8], ŌTSURU[12], and YASUDA[15,16] on the material taken by trawl from the Yellow and East China Seas. No investigation of this field has yet, however, done on the stock of this fish of Japanese waters. Moreover the age-characters found on scale and otolith are greatly diverse and variable. Wherefore the age-determination, an important item in population study of fish, is very difficult, and the results reached by previous workers are not in accordance. Then much has been left to be desired in this connection. We have of late had an opportunity to undertake a population study of the fish in question on a set of material trawled in the Tosa Bay by the Shunkotsu-maru, the training ship of our university. The results taken may be given in the following pages.

Before proceeding any further, we take this opportunity of expressing our hearty thanks to Mr. Yukiyasu SASAKI, Captain of the training ship, Mr. Yasuhiko KITAGAWA and others of the crew, by them all the material treated in the present scrutiny was imparted. Acknowlegement is also made to Mr. Daijirō KUSAKABE of the Inland Sea Regional Fisheries Research Laboratory for his kindness, he put at our disposal his unpublished data of body-length of *Sparus swinhonis* GÜNTHER taken monthly from the visinity of Kasaoka, Inland Sea. We wish also to record our thanks for the financial aid given by the Ministry of Education for pursuing the present study.

(1) Material and Method

All the fish, *Taius tumifrons*, 130 individuals, caught in two hauls on Sept. 1, 1950 in the waters (32°59.2′–33°31′ N, 133°12.3′–133°15.1′ E) of the Tosa Bay by the Shunkotsu-maru by a trawl net with a mesh of 8.25 cm, were used for the specimens, on which the present investigation is based.

Mensurations of body-weight and body-length from the tip of snout to the base of caudal fin, and sampling of scales were made on board by the crew of the ship. A number of scales were taken from about middle area above the lateral line of the trunk of the fish, and put on a paper for later examination. For reading of resting zones and measurements, all available scales were mounted on slide glass with a drop of water after the following manipulation, viz. at first the scales were sufficiently immersed in a solution of about 1% caustic potash, and then cleaned off their adherent matters. Whole scales dealt with are 602 in number. They are observed under a microscorpe. The dimension from the focus to the edge of scale and that from the focus to the anterior rim of each resting zone were measured by a micro-meter along a line running from focus to antero-lateral margine of the scale.

(2) Body-length composition

Of the body-length [a], the range, average, standard deviation and coefficient of variation are 9.0-28.5 cm, 18.74 ± 0.26 cm, 4.44 ± 0.19, 23.69 % respectively. In 1 cm grouping of the body-length ranging 9-29 cm, the frequency distribution runs as follows: 1, 0, 4, 9, 7, 7, 7, 6, 13, 15, 17, 11, 4, 6, 3, 3, 4, 6, 2, 5, and four peaks are found to exist. The first, second, third, and fourth peaks lie on body-lengths, 13–16 cm, 19–20 cm, 22–23 cm, 26–27 cm respectively as shown in the Fig. 1. As may be given in a latter section, those peaks would be referred to 0-I-age, II-age, III-age, and IV-age groups of the fish respectively.

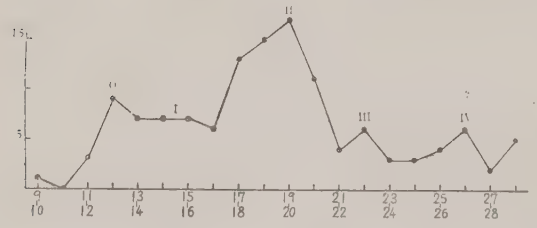

Fig. 1. Body-length composition of the present material, 130 in total number. Ordinate, frequency; Abscissa, body-length (cm). Roman numerals are showing age-class.

(3) Relationship between scale-length and body-length

The relevance between lengths of scale and body is given in the Fig. 2. Within the limit of the body-length dealt with, the regression between

a) body-weight ranges 30–990g.

those lengths given above appears to be linear, though there is a trend that the increment-ratio of scale is somewhat lesser than that of body-length in the fishes larger than those measuring 26–27 cm long. The regression line taken by least-square method may be expressed by the following formulae: $L = 3.977\ S - 4.44$ or $S = 0.251\ L + 1.167$ (Fig. 2, a), where L = body-length in cm, S = scale-length in mm. The latter formula approximates to that given by ŌTSURU [12] with regard to the fish, *T. tumifrons* of the East-China sea and the Yellow sea.

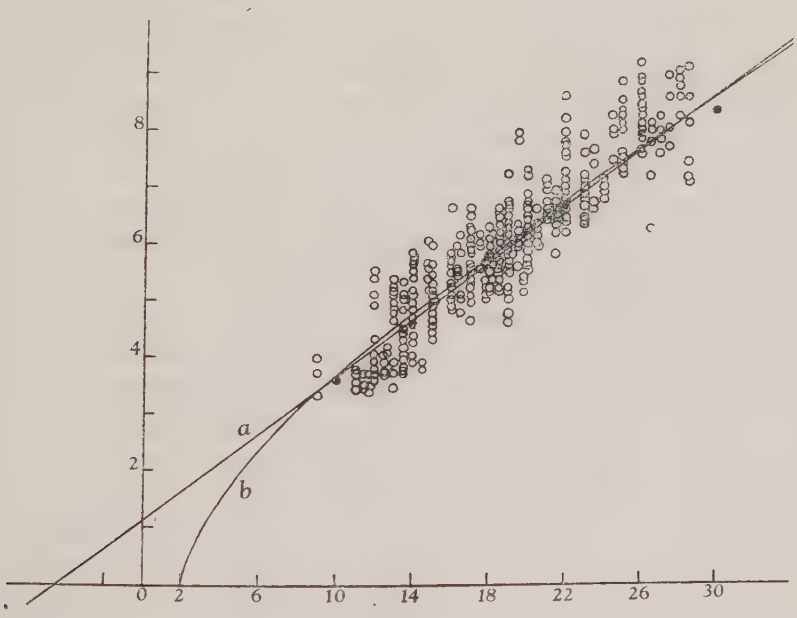

Fig. 2. Showing relationship between body-length in cm and scale-length in mm. Abscissa, body-length. Solid circles, average.

But the regression in question is referred, of course, to be a curve when the body-length, at which the scale is firstly appeared, is taken into consideration, since the scales do not appear until the fish has attained some lengths. Provisionally fixing the body-length of the young fish having scales just appeared at 2 cm [b] according to ŌTSURU and others, the relationship between lengths of scale and body may be expressed by a formula, $S = 13.258\ (L-2)^{0.687}$ (Fig. 2, b).

(b) A young of the fish with body-length 2.5 cm were caught in the sea, northeast of Formosa (Fishing ground No. 526) on Dec. 22, 1947. This has been found assuming an adult form and has been thought bearing well developed scales (ŌTSURU, 1950. pp. 53, 58).

(4) Age-determination

By scale analysis, age-determination was made. Inasmuch the resting zones lying on scale of this fish are very variable in number as set forth in latter section, and are not well defined in most cases, the recognition of true yearly ring is no easy task, at least, it has been impossible in the present material. Thus we read out all recognizable resting zones irrespective of degree of their clearness to avoid personal error of observation as possible as we can. Then it may be said that there are no omission of annual resting zones if they are defined. Moreover yearly zones are commonly believed to be defined more distinctly, even in slight degree, compared to accessory ones, and believed to be placed nearly at the same position through individuals, although it is inevitable that there is some individual variations. Accordingly it appears to be to us that the body-lengths matching to the peaks of the frequency-polygon of the resting zones against scale-length are to be corresponding to the modal body-lengths, on which the resting zones are formed.

At reading resting zones in the present study, the following four categories are set down according to their legibility:– (a) very legible, (b) legible, (c) rather legible, and (d) not legible but recognizable. The resting zones referable to the former two of these categories are defined as running to exposed portion of the scale on which they are laid down, especially those belonging to the category (a) appear with disturbance of circuli forming the zone as already pointed out by MIYOSHI[7] and KANDA[5].

The resting zones read out are 2905 in total number dealing with 602 scales (Table 1 and Fig. 3). Frequency distributions assorted by degree of legibility of these zones for each 0.5 mm interval of scale-length are given in Fig. 4. Regarding total number of the zones, eight peaks, a–h are found to exist, though three peaks of which (e, f, and h) are not well defined. Each of the peaks falls on 1.0–1.5, 2.0–2.5, 3.0–3.5, 4.0–4.5, 5.0–5.5, 6.0–6.5, 7.0–7.5, and 8.0–8.5 mm of scale-length in order of a, b,……, h respectively. Graphically taking from the relatioship between the lengths of scale and body, the body-lengths corresponding to each of the peaks, a–h, are 3.2–4.1 (3.6) (figures in parenthesis give the median value), 5.2–6.3 (5.7), 7.8–9.2 (8.5), 11.1–12.8 (12.0), 15.0–16.8 (15.9), 19.3–21.2 (20.3), 23–25 (24) cm, and 27.2–29.0 (28.1) cm respectively. Further the frequency polygons of the resting zones of very legible (Fig. 4, A), those of legible (Fig. 4, B), and those combined both of them (Fig. 4, C) may be found running well enough parallel to that of total of the resting zones (Fig. 4, D). The peaks e and f are not well defined in each case of the total-zones, legible-zones, and in the case of zones combined both very legible and legible ones (Fig. 4, B–D). But these two peaks, especially the peak–e,

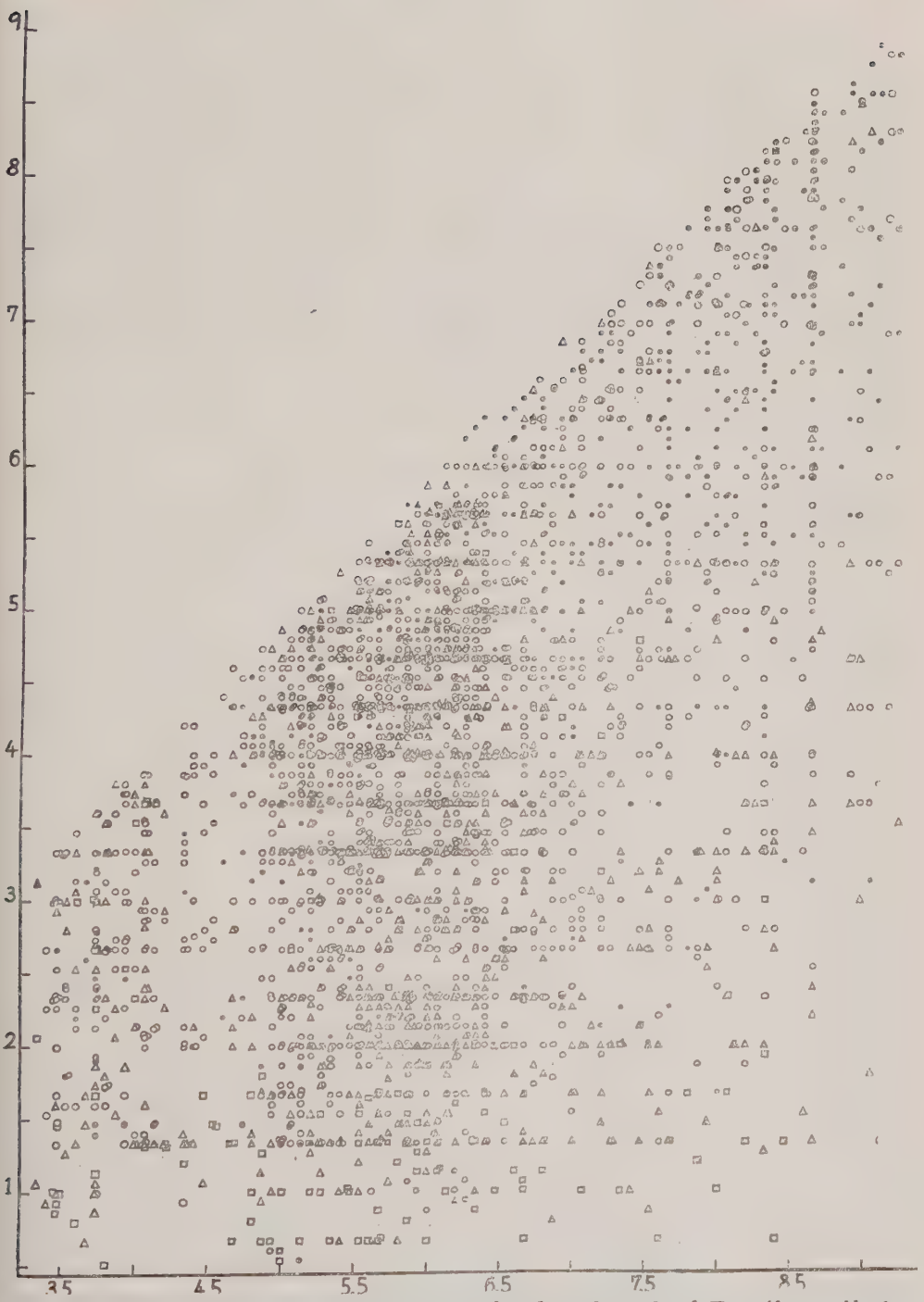

Fig. 3. Scatter diagram of the resting zones found on the scale of *T. tumifrons*. Abscissa, scale-length in mm. Ordinate, distance (in mm) from the focus to outer edge of each resting zone of the scale. Solid circles, very legible; soft ones, legible; squares, rather legible; triangles, not legible but recognizable.

are well defined in the case dealt with very legible one only. Then it appears to the writers that those two peaks are as well as being in other peaks in significance. Therefore it may be said that the mode of resting zone formation of scale happens at the time when the body and scale of the pogy measuring aforementioned lengths at least in the case of the material at hand. But the deducation of that the first annual zone coincides to which peak of the eight ones given already is not able yet by such analysis mentioned above. Now we have supposed it by the growth-rate of the young. Unfortunately we have, however, no data of such matter of the fish, *T. tumifrons* itself. So that we take the growth-rate of the fish, black sea bream, *Sparus swinhonis* GÜNTHER and snapper, *Pagrosomus major* (T. & S.).

Table 1. Frequencies of resting zones lying on scales for 0.5 mm interval of scale length.

Scale-length (mm)	Frequencies of resting zones					Total
	Very legible (a)	Legible (b)	(a)+(b)	Rather legible (c)	Not legible (d)	
0.5–1.0	1	4	5	22	8	35
1.0–1.5	10	41	51	45	72	168
1.5–2.0	7	59	66	16	58	140
2.0–2.5	23	147	170	10	126	306
2.5–3.0	22	131	153	6	53	212
3.0–3.5	31	193	224	8	88	320
3.5–4.0	23	158	181	9	59	249
4.0–4.5	53	230	283	7	79	369
4.5–5.0	63	190	253	4	47	304
5.0–5.5	97	128	225	4	36	265
5.5–6.0	59	61	120	2	24	146
6.0–6.5	70	49	119	1	10	130
6.5–7.0	49	22	71	0	5	76
7.0–7.5	54	23	77	0	4	81
7.5–8.0	37	11	48	0	1	49
8.0–8.5	32	7	39	1	2	42
8.5–9.0	8	4	12	0	1	13
Total	639	1458	2097	135	637	2905

Monthly ranges of body-length of *S. swinhonis* of six months from June to November are 10–27, 20–24, 41–88, 29–65, 67–87, and 93 mm respectively basing on the data taken by continuous collections at weedy waters in the visinity of Kasaoka, Inland Sea of Japan by Mr. D. KUSAKABE during the two

years, 1949 and ′ 50. Approximate data are published by Dr. Y. Oshima[11] as to the young of the same species of Mikawa Bay, Aichi prefecture. According to the facts noted above it may be mentioned that the fish seem to grow to a length of about 10 cm during a period of a half year in natural circumstances, since their spawning season ranges from about April to May. In snapper, a culture has done by Nishioka[9] at Ōchō, Inland Sea. According to the result taken by him, the fish grow to a length of about 2 cm in a month after its hatch, reaches to about 5 cm in total length in two months after hatch, and attains to 12 cm in overall length during six months after its development. Also Kajiyama[3] has gathered snapper youngs from verious localities of the Inland Sea. Basing on his data, the youngs obtained in November, in which it may be thought to have reached to six months-age, seem to measure about 12–13 cm in body-length. This well agrees to the Nishioka's result taken by calture. From the matters set forth above, it appears to be right to think that these fish attain a length of about 10 cm after their hatch. Snapper is a fish larger than *T. tumifrons* as it grows to about 90 cm long[10]. But black sea bream, which lengthens to about 35 cm[16] in overall length, reaches to nearly the same size with *T. tumifrons*, which grows to about 40 cm[10] in body-length. Then it would be allowed to think that the growth rate of the young of black sea bream is subequal to that of *T. tumifrons*. Thus the rate of growth in the young of the black sea bream tentatively has been emploid herewith to inspect the result taken by the present investigation. According to this management, those fish belonging to the peaks, a–d are deduced to be 0-age ones, and those of the peaks e, f, g, and h are supposed to be I-age, II-age, III-age, and IV and above-age

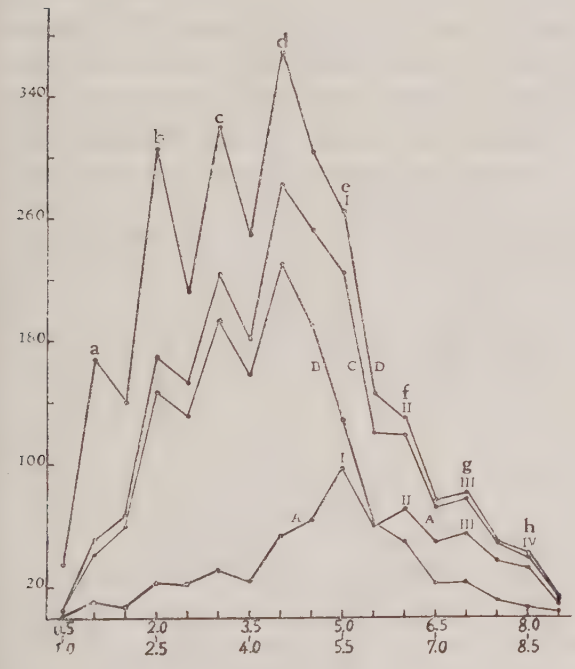

Fig. 4. Frequency distribution of the resting zones assorted by 0.5 mm of scale-length (Abscissa). A, very legible; B, legible; C, A and B combined; D, total of all the resting zones found on the scale. The peaks of the curve–D are marked in alphabetical order. Roman numerals are showing age-class.

ones respectively. Therefore the body-length of each age is guessed as follows:- less than 18.0 cm, mostly about 15.9 cm in I-age fish; 18.0-21.8 cm, mostly about 19.8 cm in II-age fish; 21.8-26.3 cm, mostly about 23.8 cm in III-age ones; more than 26.3 cm, mostly about 28 cm in IV-age ones respectively.

These supposed body-lengths of each year group well coincide to those, on which the peaks are found to exist in the Petersen-curve of the present material, viz., peaks are found standing on 13-16 cm, 19-20 cm, 22-23 cm, and 26-27 cm of body-length in the Petersen-curve of the present material as noted in the section of body-length composition. Among these, the fourth peak shows more or less disagreement, but other ones are largely well in accordance.

The result drawn from the present investigation may be compared to those taken by many previous authors in the following lines. The results published already are listed on the Table 2. According to the Table 2, the absolute values of body-length given by previous investigators for each age-class agree each other in most cases, but the standard of age-class does not conjoin. The consequence of the present investigation well agrees to that

Table 2. Calculated body length in cm by many authors. MURAYAMA's results based on otolith, all other ones are based on scale.

Items	AIKAWA	KANDA (A)	KANDA (B)	KANDA (C)	MIYOSHI	ŌTSURU	YASUDA (A)	YASUDA (B)	MURAYAMA
l_1		9.2		8.8	11	12.3	12.0	11.7	4.6
l_2	12.2	15.4	12.5	13.0	15	15.8	18.3	17.3	8.5
l_3	15.2	19.0	17.1	16.7	18	18.7	21.8	22.2	12.0
l_4	16.6	22.1	20.5	19.0	21	20.6	25.0		15.0
l_5	18.1	24.1	22.6	22.0		22.4			18.9
l_6	19.7	24.7	24.0			24.9			
l_7		25.2	24.9						

obtained by MURAYAMA[8] and YASUDA[15, 16] in absolute value, but considerably differs from that taken by other authors. The result of MURAYAMA is based on otolith, that of other authors on scale. The peak-a defined in the present study has not yet been known by previous authors. The body-length of peak-b may be corresponding to that of MURAYAMA's l_1, though the body-length of the peak-b somewhat differs from that of MURAYAMA's l_1 in absolute value. The body-length of the peak-c agrees to that of l_1 of KANDA's material A and

C, and MURAYAMA's l_2, the body-length of the peak-d to that of l_2 of AIKAWA, to that of l_2 of KANDA's material B, to that of l_1 of YASUDA's material A and B, to that of ŌTSURU's l_1, and to that of MURAYAMA's l_3 respectively. All of these given above are belonging to the 0-age group. Further the body-lengths of l_3–l_5 of AIKAWA, those of l_2 of the material A, l_3 of the material B, and l_3 and l_4 of the material C of KANDA, those of l_2 and l_3 of MIYOSHI, those of l_2 and l_3 of ŌTSUKU, and that of l_2 of YASUDA, and those of l_4 and l_5 of MURAYAMA tally to that of the group I-age inferred in this study. The body-length of l_6 of AIKAWA, those of l_3 and l_4 of the material A, l_4 of the material B, and l_5 of the material C of KANDA, that of l_4 of MIYOSHI, those of l_4 and l_5 of ŌTSURU, and that of l_3 of YASUDA agree to that of II-age group of the material at hand. Finally the body-lengths of l_5–l_7 of the material A and B of KANDA, those of l_6 and l_4 of ŌTSURU and YASUDA respectively agree to that of III-age one of our material.

In this connection the matter given in the following lines should be mentioned herein. With regard to *T. tumifrons* trawled in East China and Yellow Seas, body-length compositions of 1321, 392, 620, and 326 fishes fished during November and December, 1947, January and February of 1948, March and April of 1948, and May and June of the same year have been known by YAMAMOTO[14]. According to those, peaks are found on body-lengths of 14, 18, 20, 23, 25 cm in the material obtained in months of 1947, on those of 15, 17, 19, 21–22, 24, 26, and 28 cm of the three sets of material of 1948. These results are largely in accordance with that taken by the present investigation.

(5) Relationship of age and number of resting zones of scale

The resting zones appearing on scale of the fish, *T. tumifrons* show a strong individual deviation in number even in specimens subequal in length. Also they vary considerably in number by individual scale taken from a specimen. The relationship between age and number of resting zones read out irrespective of degree of legibility basing on a scale-material made up of 130 normal scales taken one by one from all specimens dealt with are shown in the Table 3, A. From the table the number of 0-age fish measuring 9–14.1 cm in body-length is 1–8, mostly 2–5, 3.7 on average. That of I-age fish, 14.1–18.0 cm long, ranges 0–8, mostly 3–7, 4–5 in most cases, 4.5 on average. That of II-age fish, 18.0–21.8 cm in body-length, is ranging 2–9, mostly 3–7, 6.9 on average. That of III-age fish, 21.8–26.3 cm is 3–10, 7 in 50% of all cases of this age-group. That of IV and above-age fish is 3–11, 8.5 on average. Frequency distributions of number of legible and very legible resting zones, assorted by age, are given in the Table 3, B. Referring to the table, the number of 0-age fish

is 0-8, mostly 0-4, 2.2 on average. In I-age fish, the number ranges 0-6, is 3 in most cases (ca. 42%), 3.2 on average. That of II-age fish is 1-8, 2-4 in most cases (78%), 3.5 on average. That of III-age fish is 2-8, 5-7 in most cases (75%), 5.6 on average. That of IV and above-age fish runs 2-10 being

Table 3. Age and body-length (cm) in relation to (NRZ) number of resting zones found on the scale.

(A) for all zones.

Age	Range of body-length	Renge of NRZ	Average of NRZ	Frequency of NRZ 0 1 2 3 4 5 6 7 8 9 10 11	Total
0	9.0–14.1	1–8	3.7	1 5 8 4 5 1 1 1	26
I	14.1–18.0	0–8	4.5	1 0 1 5 8 6 3 3 1	28
II	18.0–21.8	2–9	6.9	1 6 8 17 8 6 1	47
III	21.8–26.3	3–10	6.9	1 1 1 2 10 3 2	20
IV	26.3–29.0	3–11	8.5	1 1 2 2 2	9
Total				1 1 7 21 21 29 15 20 6 3 4 2	130

(B) for clear and very clear ones only.

Age	Range of body-length	Renge of NRZ	Average of NRZ	Frequency of NRZ 0 1 2 3 4 5 6 7 8 9 10 11	Total
0	9.0–14.1	0–8	2.2	4 6 5 6 3 1	26
I	14.1–18.0	0–6	3.2	2 3 1 12 4 2 4	28
II	18.0–21.8	1–8	3.5	1 11 14 12 3 4 1 1	47
III	21.8–26.3	2–8	5.6	1 2 1 3 7 5 1	20
IV	26.3–29.0	2–10	7.3	1 2 1 2 1 2	9
Total				6 10 19 34 20 9 17 7 5 1 2	130

(C) for very clear ones only.

Age	Range of body-length	Range of NRZ	Average of NRZ	Frequency of NRZ 0 1 2 3 4 5 6 7 8 9	Total
0	9.0–14.1	0–2	0.5	17 6 3	26
	14.1–18.0	0–4	1.0	12 8 5 1 2	28
II	18.0–21.8	0–5	0.6	35 4 5 1 2	47
III	21.8–26.3	0–5	2.7	4 2 3 3 4 4	20
IV	26.3–29.0	0–9	5.2	1 2 3 1 1 1	9
Total				69 20 16 5 8 9 1 1 1	130

7.3 on average. Moreover, the frequency distributions of the number of very legible resting zones only, classified for age, are given in the Table 3, C. Concerning to the table, the number of 0-age fish is 0–2, 0.5 on average. That of I-age fish is 0-4, 1.0 on average. That of II-age fish is 0–5, 0.6 on average. That of III-age fish is 0–5, 2.7 on average. In the fishes of IV-age and those of more than it, that is 0–9, 5.2 on average.

From the facts noted above, it may be mentioned that the number of the resting zones show a trend of positive correlation against body-length grouped for age, but the trend is weak in degree. In this connection, YASUDA[15, 16] has stated that the number of the resting zones of the fish is 1–5 in range, and 2 on average respectively in the first and second years of its life. In the consequence drawn from the present scrutiny, the number of very legible and legible zones is 0–6, 3.2 on average in I-age fish, 1–8, 3.5 on average in II-age fish, and 2–8, 5.6 on average in III-age one as given already. In I-age fish, the range largely tally with that given by YASUDA, but the average differs as being 3.2 in our material. As to II and III-age fish, it may be said that such trend pointed out by YASUDA is hardly recognizable. But no such trend is found to exist in the case of the zone limited for very legible one only.

(6) Some consideration on the Stock

Age-composition of the present material, based on the present method of age-determination, is given in the Table 4. Referring to the table, the number of 0 and I-age, II-age, III-age, and IV and above-age fish is 54 (41.5%), 47 (36.1%), 20 (15.3%), and 9 (6.5%) respectively. Accordingly it may be inferred that, at least, about the half of the fish trawled may belong to sexually inmature fish. The survival rate drawn from the age-composition given above is 87.0% 42.5%, and 45.0% in fishes of I, II, and III-age respectively. The withdrawal rate in per cent is 13.0 in I-age fish, 57.5 in II-age fish, and 55.0 in III-age one. The general rate of diminuation is 58.4%. This general rate approaches to that taken by ŌTSURU[12] as the rate is 63% in the material fished from the East China Sea in months November and December of 1947 and 58% in the material obtained in the same months of 1948 from the same sea.

As to condition of the stock, some considerations may be given in the following lines taking frequency rate of fishes larger than 25 cm (excluding fishes of 25 cm) in body-length for a standard. Such fish belonging to the category given here is found 12 in number in the present material. So that the frequency rate is 9.2 in per cent.

According to KAWAKAMI and MATSUI[6], the frequency rate of five sets of material trawled from the Yellow Sea during August to December, 1948 is 4.5–10.6%, 7.2% on average based on their figures. The rate of four sets of material caught from the East China Sea in November and December of 1947 and in months, January to February, March to April, and May to June of 1948 is

Table 4. Survival rate and others. *, numerals laid within parenthesis give the median value at the peack marked with roman numerals in the Fig. 4.

Age	Range of body-length (cm)	Frequency (%)	Survival rate (%)	Withdrawal rate (%)
0+1	<18.0 (15.9)*	54 (41.5)	87.0	13.0
II	18.0–21.9 (19.8)	47 (36.1)	42.5	57.5
III	21.8–26.3 (23.8)	20 (15.3)	45.0	55.0
IV+<IV	26.3< (28.1)	9 (6.5)		

1.7-4.1%, 2.6% on average basing on the figures given by YAMAMOTO[14]. Furthermore the frequency rate of the East China Sea material of 1948 is 5.4% according to KANDA[5]. As seen above, the frequency rate of the fish larger than 25 cm long of the East China and Yellow Seas stocks is somewhat less than that of the Tosa Bay stock. Accordingly it may be mentioned that the stock of the Tosa Bay is more or less in better condition compaired to that of the East China and Yellow Seas.

Summary

(1) On the body-length composition of the material which is composed of all fishes caught by two hauls by a trawl net with 8.25 cm mesh on Sept. 1, 1950 in the Tosa Bay, four peaks are found to exist on 13–16 cm, 19–20 cm, 22–23 cm, and 26–27 cm of body-length. The peaks are representing age-groups of 0–I, II, III, and IV respectively.

(2) The relationship between scale-length (S) and body-length (L) may be expressed by $S = 13.258\ (L-2)^{0.687}$ when the body-length, in which scale is firstly appeared, is taken into consideration, but it may be expressed by L=3.977 S–4.44 or S=0.251 L+1.167 within the limit of the present material.

(3) Range and median value (in parenthesis) of body-length of each age-class are 14.1–18.0 cm (15.9 cm), 18.0–21.8 cm (19.8 cm), 21.8–26.3 cm (23.8 cm), and 26.3–28.5 cm (mostly 27.2–29.0 cm) in I, II, III, and IV and above-age respectively.

(4) Slight possitive correlation is found between body-length and number of resting zones lying on the scale. The number of 0-age fish (9.0-14.1 cm long) is 1–8, mostly 2–5, 3.7 on average; that of I-age fish 0–8, mostly 3–5, 4.5 on average; that of II-age fish 3–7, 5 in most cases, 6.9 on average; that of III-age one mostly 7, 6.9 on average; and that of IV and above-age fish 8.5 on average in the case of the total resting zones. That of 0-age fish is 0–4 (2.2 on average), that of I, II, III, and IV and above-age fish is 3–6 (3.2), 2–4(3.5), 5–7(5.6), 6–10(7.3) respectively in the case of both legible and very legible zones combined.

(5) Survival rate taken from age-composition is 87.0%, 42.5%, 45.0% in 0–I, II, III-age fish respectively.

(6) General rate of diminuation is 58.4% being nearly equal to that of the stock of the Yellow and the East China Seas.

(7) Frequency rate of fish larger than 25 cm in body-length is 9.2%, this rate is a little more than that of the stock of the Yellow and the East China Seas.

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STUDIEN UEBER *GYMNOPHALLOIDES TOKIENSIS* FUJITA, 1925.

I. UEBER DIE EINWIRKUNG DER LARVALEN TREMATODA AUF DIE CHEMISCHE KOMPONENTE UND DAS WACHSTUM VON *OSTREA GIGAS* THUMBERG.*

von

Toshikazu HOSHINA und Chinkichi OGINO

(Eingegangen am 16 Jan. 1952.)

Gymnophalloides tokiensis FUJITA, 1925 ist eine larvale Trematoda, welche auf der Oberfläche des Mantels von *Ostrea gigas* parasitisch ist.

Die *Ostrea gigas*, welche in Yawata Gegend, Chiba Präf. prodeziert sind werden befallen von dieser Agamodistoma in 100% und zwar in starken Infektion gefunden. Wegen dieser starken Infektion scheinen die aus dieser Gegend stammenden Austern auffallend beschädigt zu werden. Schon von FUJITA[2] (1925) hatten die Schädigungen bei Auster beschrieben worden wie folgt; „Lorsque l'infection est intense, toute la surface du manteau est semée de groupes de parasites. Comme conséquence, la chair de l'huître devient maigre, présentant une coloration grisâtre au lieu de la coloration normale d'un blanc de lait. Même chez une coquille morte, la trace de l'infection est reconaisable: la face interne est marquée d'aspérités, que provoque toujours la presénce du parasite."

Noch dazu ist es wahrnehmbar, dass in Laichzeit bei den intensiv infezierten Austern die Aktvität des Gonads nicht genug sei.

HOSHINA der Verfasser ist seit dem Jhare 1948 an der Arbeit der biologischen Studien über diese Agamodistoma gewesen. Diese kurze Mitteilung wurde als ein Teil von deren Arbeit ausgeführt.

Bevor zum Subjekt zu kommen, an dieser Stelle mögen wir Herren A. KISHI und U. KIGUCHI unseren Dank zum Ausdruck bringen, dass unsere Untersuchungen, mit so grossen Hilfen von ihnen wie uns ihren Austerzucht Farm zur Verfügung gestellt sowie uns die notwendige Untersuchuungsmaterialien beschaffen zu haben, doch ermöglich geworden sind. Unser Dank gebührt

* Ein Teil der Ausgabe für diese Forschung ist auf wissentchaftliche Forschungskosten von Unterrichtsministerium begründt.

sodan Hern Prof. J. HORI, wer diese Untersuchungen unterstützt hatte. Ferner sind wir der verstorbenen Herren M. YOSHIZAWA und T. INABA zu Dank verpflichtet, wer durch tätkräftige Mithilfe diese Untersuchungen unterstützt hatten.

I. EINWIRKUNGEN DER AGAMODISTOMA AUF DIE CHEMISCHE BESTANDTEILE DES KÖRPERS VON *OSTREA GIGAS*.

Viele Untersuchungen über die allgemeinen chemischen Bestandteile von Austerfleische wurden von MITCHLL (1915), RUSSEL (1923), SEKINE-TATSUNO-IMAMURA (1929), MASUMOTO-MASUMOTO-HIBINO (1923-'34), OZAKI und KOBAYASHI (1929), HATANAKA (1940) usw. mitgeteilt. Diesen Autoren nach sind es folgende Tatsache festgestellt worden: die chemischen Bestandteile von Austerfleische verändern sich infolge der Jahreszeit, und bei der Reife der Reproduktionszellen erreichen jede Komponenten ihren maximalen Gehalt und sie vermindern sich rasch durch Emanation der Samen und Eier, und dabei insbesonder sind es die Veränderungen des Gehaltes von Glykogen, Eiweiss und Fett bemerklich. In den ausführlichen vergleichenden Studien über die chemischen Komponenten des Körpers von Auster haben MASUMOTO u. a.[8] nachgewiesen, dass der Glykogengehalt im Anfangsstadium der Reife von Reproduktionszellen Maximum erreicht und danach sich vermindert, aber der Fettgehalt Maximum später als der Glykogengehalt erreicht.

HATANAKA[5] hatte ein Studie über die von Mai bis Okt. dauernden Veränderungen des chemischen Bestandteils von Auster bei jeden Teilen von ihren Körper und darin hat er festgestellt, dass seine Untersuchungsergebnissen mit den obenerwähnten Forschernsuntersuchungsergebnissen übereinstimmen.

Aber die vorerwähnten Ergebnissen beteiligen sich an den Studien von gesunden Austern, aber dieartige Forschung ist noch nicht veröffentlicht, die über den chemischen Bestandteil des Körpers von Austern in kranken Zustanden, wie der normale Bestandteil von dem kranken in derselben Jahreszeit abweicht, ins klare gesetzt.

Die vorstellende Versuche wurde, um zu feststellen, dass wie die vorerwähnte Agamodistoma auf den chemischen Bestandteil des Körpers von Auster einwirkt, durchgeführt.

1. Material und Technik.

Die zu den Versuchen benutzten Materiallien wurden am 18. Mai, 1948 bei Yawata Gegend, Chiba Präf. gesammelt. Sie besteht aus fünf Gruppen wie folgt:

Die Gruppe A—sind die von der Agamodistoma sehr stark befallenen Austern (fast ganze Oberfläche des Mantels von ihr befallen). Sie wurden auf Grunde gezucht, 4 Jahre alt.

Die Gruppe B—sind mit geringeren Infektion als Gruppe A. Das übrige gleicht der Gruppe A.

Gruppe C—sind mit einige hundert Agamodistomen angesteckt. Sie sind nach Formosa-Methode* gezucht, 2 Jahre alt.

Gruppe D—sind am geringsten befallen. (von Dutzende von Agamodistomen befallen). Das übrige gleicht der Gruppe C.

Gruppe E—Diese ist als Kontrolle benutzt. Die Austern in dieser Gruppe sind nach der Hängendenmethode gezucht und haben keine Agamodistomeninfektion, 2 Jahre alt.

In der Tab. 1. ist die Messung der obenerwähnten Matteriallien zusammengestellt.

Tab. 1. Die Grösse der untersuchten Materiallien.

Gruppe	Gewicht g	Fleischgewicht g	Schalenhöhe mm	Schalenlänge mm	Schalentiefe mm
A	72.5–109.0	12.5–17.7	116–159	43–52	24–34
	(87.96)	(14.26)	(132.8)	(50.0)	(31.0)
B	62.0–85.5	9.9–16.0	73–96	45–54	26–40
	(74.40)	(13.20)	(81.0)	(49.6)	(31.8)
C	21.5–41.0	6.0–10.1	62–80	33–43	19–35
	(33.10)	(7.80)	(67.8)	(36.8)	(27.8)
D	13.0–60.0	2.6–17.0	48–70	31–47	15–38
	(35.10)	(8.50)	(61.2)	(42.0)	(26.4)
E	43.5–67.5	9.0–19.5	68–91	45–60	22–34
	(55.80)	(13.78)	(84.0)	(53.8)	(27.0)

Jede Gruppe inhält fünf Austern. Die Ziffer in der Klammer zeigt die Durchschnitt.

Die Schalen wurden geöffnet und nach den Ausflussigkeiten wurde ihr Fleischgewicht gemesst. Dann nahm man dasselbe Fleisch (für 5 Austern) in den Mörsern ein und es wurde fein zerreibt und dieselben Matteriallien wurden benutzt zu analysieren.

Die Bestimmung des Wasser = und Aschegehalts erfolgte nach den üblichen Methoden. Das Glykogen wurde nach Pflüngersche Methode, die Glukose nach Hagedorn-Jensensche Methode, der Stickstoff nach Kjeldahlsche

* Diese Methode von Austerzuchtung ist wie folgt: Man bindet die Muschelschalen (Sammler) mit den jungen Schaltieren von Austern mit Drahten in bestimmten Abständen an den Stecken des Bambuses und stellt dieselben in der See-Gründe gesteckt.

Methode, der Eiweiss-N nach Stutzersche Methode und der Fett nach Kumagawa-Sudosche Metode[16] bestimmt. Ferner für die Analyse der Asche arbeiteten haben wir folgende Methode aus: die Asche wurde in der verdünnter Salpetersäure gelöst und das Volumen wurde bestimmt gemacht davon nahm man die bestimmte Menge von Probe ein und Ca und Mg wurden nach den üblichen Methoden, Fe nach kolorimetrischen Methode und Na nach Barber-Kolthoffscher Methode[1] gemesst.

2. Untersuchungsergebnis.

In der Tab. 2. und Fig. 1. fassen wir die gewonnen Analysenzahlen über die allgemeinen Bestandteile der verschiedenen Austergruppen zusamen.

Tab. 2. Allgemeiner Bestandteil.

Material / Gegenstand	A	B	C	D	E
Wasser	83.6%	78.2%	77.9%	75.1%	75.1%
Trocken Substanz	16.4	21.8	22.1	24.9	24.9
Asche	2.32	2.19	2.33	2.66	1.97
Glykogen	1.81	2.41	3.18	3.54	3.31
Gesamt-N	1.262	1.359	1.688	1.783	1.846
Nicht-Eiweiss-N	0.241	0.171	0.283	0.300	0.236
Eiweiss-N	1.021	1.188	1.405	1.483	1.610
Eiweiss	6.38	7.42	8.78	9.27	10.06
Fett	0.623	1.53	2.73	1.98	3.01

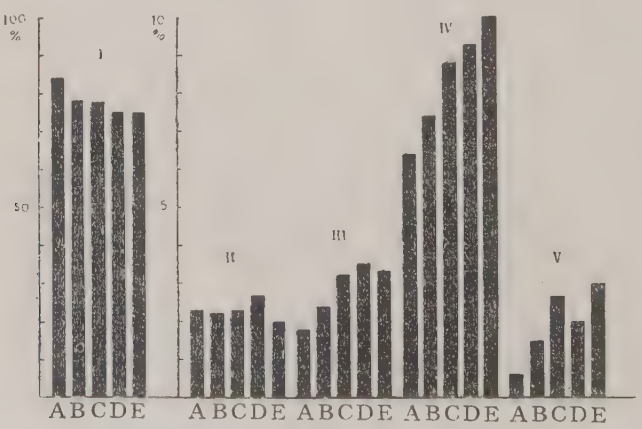

Fig. 1. Graphische Darstellung des Analysenzahls.
A =Gruppe A, B= 〃B, C= 〃C, D= 〃D, E= 〃E.
I =Menge des Wassers, II=Menge der Asche,
III= 〃Glykogens, IV= 〃Eiweisses, V= 〃Fettes.

Aus der Tab. 1. und Fig. 1. ersieht man, dass bei den befallenen Austern von der Agamodistoma die Menge des Glykogens, Eiweisses und Fettes wenig und die jenige des Wassergehalts gross. Und je grosser die Befallenstärke der Agamodistoma ist, desto mehr der Wassergehalt verstärkt sich und desto geringer wird der Gehalt des Glykogens, Eiweisses und Fettes. Aber wenn man die geringst infizierte Gruppe D mit der Gruppe E (Kontroll) vergleicht, enthält die Gruppe D grössere Glykogenmenge als Gruppe E und die Menge des Eiweisses und Fettes sind grösser in der Gruppe E als die Gruppe D. Ausserdem bei der Gruppe E, im Vergleich mit den Agamodistomen infizierten Gruppen, ist die Aschegehalt besonders wenig, während die Fettegehalt sehr gross ist.

Diese Schwankungen vermutlich können nicht in der Infektionsdasein oder Nichtdasein von der Agamodistoma, sondern vielmehr in der Zuchtungsverschiedenheit begründet.

Bei jeder infizierten Gruppen (A-D) sind die Menge des Asches und nicht-Eiweiss-N ausserordentlich schwankend und man kann nicht die Veränderungen von diesen Bestandteilen als durch die Agamodistomeninfektion entschieden betrachten.

Die Analysenzahlen des Asches von jeden Gruppen sind in der Tab. 3.

Tab. 3. Der Gehalt der Ca, Mg,Fe, und Na.

Material / Gegenstand	A	B	C	D	E
Ca	0.13%	0.15%	0.18%	0.22%	0.072%
Mg	0.12	0.10	0.11	0.11	0.16
Fe	0.0047	0.0025	0.0048	0.0068	0.0075
Na	0.11	0.037	0.032	0.057	0.12

niedergelegt. Bei Vergleichung dieser Befunde ergibt sich die auffallende Unterschied zwischen den infizierten Gruppen und der Gruppe E, dass die Gruppe E durch die viele Menge von Mg und Fe, und geringe Menge von Ca gekennzeichenet ist. Diese Unterschiede sind wahrscheinlich in der Zuchtungsverschiedenheit begründet. Aber beim Vergleich der infizierten Gruppen je mehr die Befallenstäke der Agamodistoma, ist desto weniger ist der Calciumgehalt.

Auch die Menge des Eisens zeigt die Neigung zur Verminderung in der Gruppen, deren Infektion stark ist. (A. B. und C.). Über die Menge des Natriums haben wir nichts sicheres zu sagen.

II. EINWIRKUNG DER AGAMODISTOMA AUF DES WACHSTUM DER AUSTER.

Bis zur Gegenward haben solche Gelehrte wie NELSON (1922). SENO und HORI (1927), ORTON (1935), LOOSANOFF und NOMEJKO (1949) etc. über das Wachstum von Austern gearbeitet. LOOSANOFF uud NOMEJKO hatten eine ausführliche Studie über das Wachstum von *O. verginica* und ihre Wachsenproportion von Gewicht, Volumen, Schalenhöhe, Schalenlänge und Schalentiefe auf jedem Monate im Jahre festgestellt.

Aber diese alle sind die Arbeiten über die gesunden Austern. Die Forschung ist noch nicht veröffentlicht, über das Wachstum von Austern, welche durch Infektion von irgendeinen Parasiten im Abnormzustande sind.

Folgende Arbeit ist versucht worden, um die Einwirkung der bereiterwähnten Agamodistoma auf die Wachstum von Auster zu prüfen.

1. Material und Technik.

Die zu den Versuchen verwandten Austern sind aus Kurihama in Kanagawa Präf., im natürlichen Zustande und sehr seltsame Fall ausgenommen waren frei von Infektion mit der Agamodistoma. Und wenn sie auch von der Agamodistoma befallen würde, so wären einige Agamodistomen nur dann in der infizierten Auster zu erkennen.

Um diese Austern mit der Agamodistoma befallen zu lassen, wurden sie aus Kurihama vergesetzt in einem Ort von See-Ufer von Yawata, Chiba Präf., wo die natürliche Infektion von derselben Agamodistomen im Schwange war.

Nach dem Verlauf von dem bestimmten Zeitraum wurden sie wiedergesammelt, uud Gewicht, Schalenhöhe, Schalenlänge und Schalentiefe derselben gemesst und dann mit Zelluloid markiert. Dann wurden die andern Austern aus Kurihama für Kontrolle gesammelt und gemesst und markiert. Für Zuchtung wurden die beide Gruppen von Austern im Drahtkäfig aufgenommen und in der Tiefe von ein Meter in der See von Hern Kishis Austerzuchtanstalt (Kimizuka) in der Nähe Yawata gehängt, wo die natürliche Infektion von der Agamodistoma gewöhnlich nicht vorkommen ist. Und nach dem Zuchtung von einer bestimmten Zeitraum wurde die Wachstum von beider Austergruppen vergleicht.

2. Versuch 1. und dessen Ergebnis.

Die Versuch wurde von 24. Juli 1949 bis zum 6. Dezember 1949 angestellt. Zuerst wurden zur Herstellung des Infektionsmaterials am 24. Juli 1949 etwa

100 Stücke der Austern (vermutlich 2 Jahre alt) aus Kurihama in See-Ufer Yawata versetzt und am 21. August 1949 wiedergefangen. Beim Fang konnten wir 21 Stücke von derselben Austern sammeln und diese 21 Stücke der Auster wurden für dem Versuche benutzt. Noch dazu, am 20. August 1949 wurden die andern Austern in Kurihama gesammelt und 20 Stücke davon wurden für Kontrolle des Versuches benutzt.

Nach der Messung von der Versuchsmateriallien am 21. August 1949 wurden sie am obenerwähnten Ort gehängt.

Die Wassertemperatur (in der Tiefe von ein Meter) des Versuchsortes während des Versuchses war wie folgt:

August	Sept.	Okt.	Nov.	Dez.
27.2°C.	23.2 〃	15.5 〃	9.5 〃	10.5 〃

(Dies ist nicht die Ergebnis von täglichen Beobachtungen).

Die spezifisches Gewicht schwankte sich im Umfang von 1.02152–1.02368.

Tab. 4. Wachstum von Versuchsgruppe und Kontrollegruppe im Austerzuchtanstalt zu Kimizuka, Chiba, Präf..

	Material u. Abschnitt \ Gemessengegend		Gewicht g	Schalehöhe mm	Schalenlänge mm	Schalentiefe mm
Versuchusgruppe	Variationsbreite	1	6.0–15.8	33–54	23–37	14–25
		2	13.7–37.9	44–76	37–53	17–26
		3	7.7–23.0	11–26	8–18	3–7
	Durchschnitt	1	10.40	41.7	31.0	18.2
		2	26.46	60.0	43.0	23.8
		3	16.06	18.3	12.0	5.6
	Standarddeviation	1	2.896	4.27	4.22	2.88
		2	7.526	8.39	6.14	3.88
		3	4.876	4.22	2.74	1.38
Kontrollegruppe	Variationsbreite	1	6.5–14.4	30–46	24–33	13–21
		2	15.5–38.5	44–67	35–45	17–27
		3	9.0–24.4	14–26	9–14	3–8
	Durchschnitt	1	11.11	40.0	30.0	16.5
		2	28.42	59.5	42.0	22.2
		3	17.31	19.5	12.0	5.7
	Standarddeviation	1	2.925	5.15	2.87	2.61
		2	6.473	6.57	4.20	3.49
		3	5.187	3.68	1.81	1.95

Anmerkung: Die Zahl der gemessenen Austern sind 13 in der Versuchsgruppe und 11 in der Kontrollegruppe.
1…Vor Zucht. (Die gestorbenen Austern während des Zuchtungs wurden ausgeschlossen), 2…Nach Zucht. 3…Zuwachs.

Nach der 106 Tage Zuchtung von 24 Juli 1949 bis zum 6. Dezember 1949, wurden sie geprüft. Bei der Prüfung wurden 7 Stücke der Austern in Versuchsgruppe und 8 Stücke in der Kontrollegruppe tod gefunden (In der Kontrollegruppe während des Zuchtungs ist eine Auster verloren). In der Versuchsgruppe war die Befallszahl der Agamodistoma in einem Auster 240-513, durchschnitt. 403.3. Auch in der Kontrollegruppe wurden zwei infizierten Auster mit der Agamodistomen gefunden, aber die Befallszahl war 3 od. 9 bzw..

Die Ergebnisse sind in Tab. 4. u. 5. zusammengestellt.

Tab. 5. Prozentsaz von Zuwachs.

Material u. Abschnitt \ Gegenstand		Gewicht	Schalenhöhe	Schalenlänge	Schalentiefe
Versuchsgruppe	Variationsbreite	110.1–176.7	31.8–56.5	27.6–48.0	15.0–43.8
	Durchschnitt	149.2	43.9	38.9	30.7
	Standarddeviation	24.40	8.51	7.59	7.58
Kontrollegruppe	Variationsbreite	104.5–189.3	36.8–76.4	31.3–45.8	25.0–44.4
	Durchschnitt	153.9	49.6	40.0	34.6
	Standarddeviation	24.92	10.67	4.84	5.19

Wie aus Tab. 4. u. 5. hervorgeht, wurde es beobachtet dass die Versuchsaustern etwas den Kontrolleaustern an Wachstum nachstanden mit Ausnahme von nur einer Auster, welche im Zuwachs an Gewicht als der Versuchsgruppe nachstand. Aber der Unterschied des Zuwachses zwischen Versuchsgruppe und Kontrollegruppe ist nicht auffallend. Und die Zuwachsdifferenz in dem Wachstum von Gewicht, Schalenhöhe, Schalenlänge und Schalentiefe zwischen diesen beiden Gruppen haben im statistischen Zustande der Prüfung keine Bedeutung. Daher scheint es, dass bei der solchen Befallstärke wie durch ungefähr 400 Agamodistomen, das Wachstum der Auster nicht so sehr beeinflusst wird.

Der Wert des Fleischgewichts für das Muschelgewicht in Prozentsatz war folgende:

	Variationsbreite	Durchschnitt	Standarddeviation
Versuchsgruppe	19.6–29.9%	26.3%	3.68
Kontrollegruppe	24.4–32.7 〃	29.5 〃	2.18

Nämlich ist der Mittelwert des Fleischgewichts für das Muschelgewicht in Prozentsatz im Falle der Kontrollen grosser als im Falle der Versuchs. Die Differenz der obenerwähnten Mittelwerte kann man nach der Prüfung von t-Verteilung mit 5% Gefahrsatz bedeutsam anerkennen.

Danach ist es klar, dass die Versuchsaustern im Mästen schlecht sind, d. h. nicht mastig.

Nächst nur über den Wasser- und Glykogengehalt der obenerwähnten Materiallien wurde ein Versuche gemacht, ob sie in dem Körperbestandteile sich unterscheiden, oder nicht.

Die Herstellung des Analysematerials wurde sofort nach dem obenerwähnten Versuche durchgeführt. Fünf Austern jeder für sich wurden aufs Geratewhol aus beiden Gruppen eingenommen im Mörsere fein gerrieben und für die Analyse gelifert.

Die Ergebnisse der Analyse:

	Wassergehalt	Trockensubstanz	Glykogengehalt
Versuchsaustern	84.22%	16.78%	2.80%
Kontrolleaustern	78.92 〃	20.08 〃	3.74 〃

Wie oben dargelegt, wurde es ziemlich grosser Unterschied im Wassergehalt und Glykogengehalt zwischen den Versuchsaustern und den Kontrolleaustern erkannt. Auch in diesem Falle ergab sich es, dass in den Versuchsaustern der Wassergehalt viel und der Glykogengehalt gering ist. Doch in diesem Falle, mit dem vorerwähnten Versuche zu vergleichen (s. Tab. 2.), sind beide, viel im Wassergehalt, und vermütlich ist es begründet auf den Differenz von Jahreszeit und Stamm der Auster.

3. Versuch 2. und dessen Ergebnis.

Der Versuch wurde von 2. Juli 1950 bis zum 4. Mai 1951 angestellt.

Material, Technick und der Ort des Versuchs sind nicht von derjenigen beim Versuche 1. verschieden. Um die infizierten Materiallien mit der Agamodistoma zu bekommen, am 2. Juli 1950, wurden etwa 300 Austern aus Kurihama in Yawata vergesetzt. Und am 11. August 1950 wurden sie wiedergesammelt, aber konnten nur 23 Austern wiedergefangen werden.

Diese 23 Austern wurden für den Versuch geliefert. Nachdem wurden die Messung und Markierung von diesen Versuchsmateriallien durchgeführt, dann wurden sie mit der Kontrolleaustern (Die Materiallien wurden aus Kurihama am 10. August 1950 gesammelt und 30 Stücke davon wurden für den Versuch benutzt) in den Drahtkäfig (40 cm × 40 cm × 10 cm) eingesetzt und am 11. August 1950 wurden in die See Gehangt. Im Laufe der Zuchtung wurden die Wassertemperature und das spezifisches Gewicht nicht beobachtet.

Die Versuchstieren wurden am 4. Mai 1951 (nach 265 Tage) wieder aus den See herausgenommen und wurden wiedergemesst. In diesem Falle wurden 10 Austern aus der Versuchsgruppe und 13 Austern aus der Kontrollegruppe tod gefunden.

Die Befallstärke von der Agamodistoma in der Versuchsgruppe so gross war, dass 921–3675 Agamodistomen (durchschnitt. 1642) pro Individuum gefunden wurden. Auch in der Kontrollegruppe wurden die 10 von der Agamodistoma infizierten Austern gefunden und die Befallszahl von Agamodistomen war 25–64 pro Ind.. Diese Infektion wurde sich vielleicht im Verlaufe von der Zuchtung ergeben.

Die Tatsache dieser Infektion wird uns vielleicht zeigen können in diesem Orte auch in irgend einem Jahre geringste Infektion sich ergebe.

Die Untersuchungsergebnissen wurden in der Tab. 6. u. 7. niedergelegt.

Tab. 6. Zuwachs der Auster von der Versuchsgruppe und der Kontrollegrppe im Zeitraum von 11. August 1950 bis zum 4. Mai 1951, auf dem Austerzuchtanstalt zu Kimizuka, Chiba Präf..

Material u. Abschnitt \ Gemessengegend		Gewicht g	Schalenhöhe mm	Schalenlänge mm	Schalentiefe mm
Versuchsgruppe					
Variationsbreite	1	11.0–18.7	37–55	26–43	16–22
	2	24.5–52.4	56–88	20–30	20–30
	3	13.0–33.7	16–33	11–23	4–10
Durchschnitt	1	13.02	44.1	35.5	19.2
	2	34.98	68.5	52.0	25.7
	3	21.96	24.4	16.5	6.5
Standaddeviation	1	5.522	4.50	4.13	2.33
	2	7.076	8.99	7.39	3.27
	3	4.237	5.23	4.06	1.82
Kontrollegruppe					
Variationsbreite	1	8.0–20.0	37–55	26–45	11–24
	2	22.0–61.5	59–91	39–45	21–32
	3	14.0–41.5	20–36	13–26	6–11
Durchschnitt	1	12.43	42.9	32.6	18.8
	2	36.01	70.8	50.3	27.5
	3	23.58	27.9	17.7	8.7
Standarddeviation	1	3.479	5.99	4.65	3.56
	2	9.504	8.71	7.75	4.19
	3	6.758	4.40	3.84	1.63

Anmerkung: Die Zahl der gemessenen Austern sind 13 in der Versuchsgruppe und 17 in der Kontrollegruppe.
1…vor Zucht (Die gestorbenen Austern auf der Zuchtung wurden ausgeschlossen), 2…nach Zucht., 3…Zuwachs.

Wie aus der Tab. 7. hervorgeht, besteht ziemlich grosser Unterschied in

dem Mittelwert des Zuwachs in Prozentsatz von Gewicht, Schalenhöhe, Schalenlänge und Schalentiefe zwischen der Versuchsgruppe und der Kontrollegruppe.

Tab. 7. Zuwachs im Prozentsatz.

Material u. Abschnitt \ Gegenstand		Gewicht	Schalenhöhe	Schalenlänge	Schalentiefe
Versuchsgruppe	Variationsbreite	115.0–208.0	40.0–71.1	31.5–61.5	21.1–58.8
	Durchschnitt	169.0	55.3	46.4	34.8
	Standarddeviation	28.770	8.34	9.44	9.84
Kontrollegruppe	Variationsbreite	145.0–230.0	43.6–86.9	39.1–71.9	30.4–76.9
	Durchschnitt	196.0	65.7	53.7	47.6
	Standarddeviation	24.254	70.91	8.89	12.69

Aus der Tab. 7., rechnet man den zuversichtlicher Umfang von jedem Mittelwert auf Vertrauensgrad von 95%, so sind sie in der Tab. 8. niedergelget.

Wenn man den oben Wert miteinander vergleicht so werden beide Vertrauensintervalle vom Gewicht, der Schalenhöhe und Schalenlänge übereinander liegend gefunden. Aber ziemlich grosse Verschiebungen befinden sich zwischen jeden beiden Vertrauensintervallen. Die beiden Vertrauensintervalle von Schalentiefe des Zuwachses in Prozentsatz legt sich nicht fast aufeinander.

Deshalb kann man mit der Gefahrsatz von 5% die Bedeutung der Mittelwertsdifferenz von Zuwachs in Prozentsatz von jeden Abschnitten schwerlich vermuten.

Ferner nach t-Verteilung diese Mittelwertsdifferenzen auf die Probe gestellt, so wurden gleich ihre Bedeutungen schwerlich erkannt.

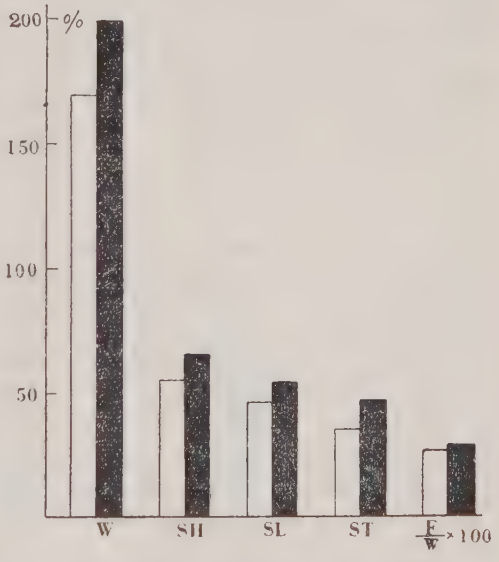

Fig. 2. Graphische Darstellung des Zuwachses in Prozentsatz.
□ = Versuchsgruppe ■ =Kontrollegruppe. W=Gewicht, SH=Schalenhöhe, SL=Schalenläge, ST=Schalentiefe, $\frac{F}{W} \times 100$=Fleischgewicht für Muschelgewicht in Prozentsatz.

Nämlich kann man sagen, dass die Versuchsgruppe im Wachstum als Kontrollegruppe nachsteht.

Tab. 8. Zuversichtlicher Umfang des Mittelwertes auf 95% Vertrauensgrad. (Zuwachs in Prozentsatz)

Material / Abschnitt	Versuchsgruppe	Kontrollegruppe
Gewicht	169.0±18.12%	191.2±12.85%
Schalenhäche	55.3± 5.25 〃	65.7± 5.78 〃
Schalenlänge	46.4± 5.94 〃	53.7± 4.71 〃
Schalentiefe	34.8± 6.20 〃	47.5± 6.73 〃

Fleischgewicht für Muschelgewicht in Prozentzatz (s. Fig. 2.) ist wie folgt:

	Variationsbreite	Durchschnitt	Standarddeviation
Versuchsgruppe	18.6–30.1%	25.5%	3.41
Kontrollegruppe	24.7–34.0 〃	28.7 〃	2.92

Durch Prüfung nach t-Verteilung ist die Differenz von diesen beiden Mittelwerten bei $\alpha=0.05$ bedeutsam. Nämalich ist es mit Gefahrsatz von 5% zu sagen, dass der Fleischgewichtprozentsatz für Muschelgewicht von der Kontrollegruppe grosser als derselbe von der Versuchsgruppe ist.

Nächst zeigt man die Fleischgewichtprozentsatz für Muschelgewicht und Befallszahl von der Agamodistoma in der Versuchsgruppe, wie folgt.

Nr. d. Auster	Muschelgewicht g	Fleischgewicht g	$\frac{\text{Fleischgewicht}}{\text{Muschelgewicht}} \times 100$ %	Zahl der Parasiten
2	32.3g	6.2	18.6	3675
3	52.4	12.9	24.6	1912
5	44.6	17.0	26.8	1942
6	31.8	7.8	24.5	983
7	32.1	6.2	19.3	2205
8	42.2	11.2	26.5	1025
10	37.0	9.3	25.1	2750
11	38.3	10.6	27.7	1563
12	36.5	11.0	30.1	921
13	27.6	8.4	30.4	903
18	27.0	7.6	28.1	1035
21	24.5	5.9	24.1	1050
23	28.5	7.7	26.0	1253
Durchschnitt			25.52%	1678

Rechnet man aus diesem Daten den Korrelationskoeffizient von Fleischgewichtprozentsatz für Muschelgewicht: Agamodistomenbefallszahl, so der Korrelationskoeffizient $r=-0.692$. Und wenn man diesen Korrelations-

koeffizient r=—0.692 nach t-Verteilung auf die Probe stellt, so kann man mit gefahrsatz von 1% die nulle Hypothese, dass Korrelationskoeffizient von Population, der Null gleiche, verlassen. Also ist r=—0.692 bedeutsam. Daher wird es anerkannt, dass die entgegengesetzte Korrelation zwischen dem Fleischgwichtprozentsatz für Muschelgewicht und der Agamodistomenbefallszahl sich befindet. Deshalb mag der Einfluss der Parasiten auf Mastigkeit nicht wenig sein.

* * *

In diesem Versuche aus den Austern von der Versuchsgruppe wurden mehrere Austern gefunden deren Schaleninnenoberfläche abnorm waren, d. h., es gab die Flecken von Erosion an der Innenoberfläche von Schalen und der Teil derselben färbte sich rötish braun od. schmützig graugrün und war rauh wie FUJITA (1925) geschrieben. Diese Krankheitsveränderung ist in der Gegend des Umbo heftig, weil die Agamodistomen sich so viel auf dem Mantel nahe dem Umbo befinden. Bei den Versuchsaustern im Falle von Versuchs 1. konnte man die Krankheitsveränderung nicht finden. Daher sheint es, solche Veränderung werden mindestens im Verlauf von acht Monate gesehen, seit die Austern mit der Agamodistoma infiziert wurden. Noch dazu ist es wahrscheinlich, dass, um sich die Veränderung zu befinden, die Infektion mit ziemlich vielen Agamodistomen notwendig sei.

III RÜCKBLICK

Unter der chemischen Analyse wurde es festgestellt, dass in den infizierten Austern mit Gymnophalloides tokiensis vieles Wassergehalt und in einer weniger Menge Glykogen, Eiweiss und Fett enthalten hatten. Es ist nicht unglaublich, dass diese Veränderung daraus hervorkommt, dass infolge der Infektion vom Parasiten die Austern im kranken Zustande sind, weil die Fleische der stark infizierten Austern einen abnormalen Anschein darstellen, wie FUJITA erwähnt (s. 1.). Auch die Analysenzahlen zeigen den entsprechenden Wert zur Befallsstärke von Parasiten.

Über die anorganischen Bestandteile wurden die grossen Veränderungen nicht beobachtet. Sie schienen vielmehr als der aus dem Parasiten hervorkommen Einfluss, wegen Alters, Bewohnungsorts und Wachstumskondition sehr verändert zu sein.

Aber es scheint, Ca und Fe sich je nach der Befallsstärke vermindern.

Durch Zuchtungsversuche mit befallenen Austern vom Parasiten und den Austern frei von der Infektion (Streng genommen, eine Anzahl von ihnen, die mit dem Parasiten sehr schwach infiziert waren) wurde es beobachtet, dass

die ersteren in Zuwachs im Vergleich mit den letzteren unterstand. Aber beim Versuche 1. gab es nicht die bedeutsame Differenz im Zuwachse von beiden Gruppen. Auch beim Versuche 2. kam die grosse Differenz nicht vor. Es wäre vielleicht wegen der schwachen Infektion, aber bei starken Invasionen ist es leicht zu vermuten, dass der Einfluss stark sei.

Bei unserem Versuche hatte man in den Versuchsgruppen sowie in den Kontrollegruppe grosser Variationen von Gewicht, Schalenhöhe, Schalenlänge und Schalentiefe im Zuwachse beobachtet. Uns dünkt, dieartige grossen Variationen des Zuwachses vielleicht darauf begründt, dass die zu den Versuche benutzten Austern wahrscheinlich nicht im gleichen Alter wären und auch dass, was gleichartige Population zu sein scheint, wie LOOSANOFF und NOMEJKO (1949) schon hingewiesen hatte, eine Verschiedenheit in den Wachstumsgeschwindigkeiten hätte.

Noch ist es bemerkenswert diese Austern nicht normal gewachen war, weil sie am Kai dicht gedrängt. Und ihr Wachstum bei diesem Versuche war im Vergleich mit dem allgemeinen nicht gut.

Der Mittelwert des Fleischgewicht in Prozentsatz für Meschelgewicht auf Vertrauensgrad von 95% war wie folgt:

	Versuchsgruppe	Kontrollegruppe
Beim Versuche 1.	26 3±2.70%	29.5±1.60%
〃 2.	25.5±2.33 〃	28.7±1.55 〃

Auch diesen Werten sind sehr klein im Vergleich mit allgemeinen Zuchtaustern. Nach SENO und HORI[15] werde es hingewiesen, dass das Fleischgewicht in Prozentsatz für Meschelgewicht mehr als 50% bei guter mastiger Auster war. Die Tatsache, die beim unserem Versuche das Zuwachs und die Mastigkeit nicht gut waren, mag auf Schlechtigkeit von dem sogenannten Stamm begründet sein, ausserdem kann man vielleicht den Einfluss der Organismen welche am Drahtkäfig angehalten, nicht übersehen.

Aus der Schlechtigkeit des Wachstums und Mastigkeit von Austern infolge der Infektion mit den Parasiten kann man schliessen, dass ihre Lebenskraft sich durch verschiedenen Schädigungen vom Parasiten vermindert. Aber die Sterblichkeit von Austern wird dadurch kaum im natürlichem Zustande beobachtet. Bei unserem Versuche war die Sterblichkeit von Austern wie folgt.

	Versuchsgruppe	Kontrollegruppe
Beim Versuche 1.	38.1%	40.0%
〃 2.	43.4 〃	43.3 〃

Uns dünkt, dass diese Sterblichkeiten sehr hoch sind aber wirklich sind es nicht so hoch.

Mehre Sterblichkeit wurde bei den Austern in dem Austerzuchtfarm wo dieser Versuch ausgeführt, als die obenerwähnten Zahl beobachtet. Es ist nicht selten, dass bei der Austerzucht nach Hängende Methode bisweilen hohe Sterblichkeit vorkommt.

Mag es sein, wie es will, man kann die Schädigung des Parasiten auf Austern absichtlich beachten. Nach der Schmarozermodus des Parasiten geurteilt, scheinen ihre Krankheitsschädigung hauptsächlich aus der Nahrungsentziehung und dem Stoffwechselprodukte zu entstehen.

IV ZUSAMMENFASSUNG.

Als Ergebnis unserer Untersuchung über die Einwirkungen auf die chemische Komponente und das Wachstum von Auster von der *Gymnophalloides tokiensis* FUJITA, 1925, der auf *Ostrea gigas* THUNBERG parasitische larvale Trematoda, ist zu buchen, wie folgt;

1. Die infizierten Austern mit dem Parasiten enthält vile Wassergehaltund geringe Menge des Glykogens, des Fettes und des Eiweisses in ihrem Fleisch. Insbesonder vermindert sich die Menge des Glykogens und des Fettes.
   Diese Veränderungen entsprechen der Befallenstärke vom Parasiten.
2. Obwohl die anorganischen Bestandteile wegen des Alters, Bewohnungsorts und der Wachstumskondition sehr veränderlich sei, aber scheint es, dass die Menge des Ca und Fe sich jenach der Befallenstärke von Parasiten vermindert.
3. Die starken infizierten Austern mit dem Parasiten erweisen die Verminderung von ihrem Wachstum. Noch dazu Werden sie nicht mastig. aber bei derartiger Infektionsstärke, d. h. dem Infektions grad von 900—3600 Parasiten / eine Auster (11—18g gross) wird so grosser Einfluss nicht beobachtet.
4. Die entgegengestzte Korrelation befindet sich Zwischen Fleischgewicht in Prozentsatz für Muschelgewicht und der Befallszahl von Parasiten.

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ON THE DIFFUSION OF SALINITY IN A HORIZONTAL CURRENT FIELD

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ABSTRACT

In this paper the theory of diffusion of salinity (in sea waters) in a horizontal current field already propounded by several authors is extended to include the case where the horizontal current velocity is any function of time. For the sake of simplicity, as an example, it is assumed that the line sink of salinity exists from $y=-l$ to $y=l$ along the infinite straight coast-line bounding one end of a sea of uniform depth and of semi-infinite extent and that as a horizontal current is considered a tidal current (with a period T) flowing parallel to the coast-line. Then, the distribution of salinity is given by solving the differential equation of eddy diffusion of salinity in a non-stationary state, taking only the terms of the horizontal mixing ($k_1 \frac{\partial^2 S}{\partial x^2}$ and $k_2 \frac{\partial^2 S}{\partial y^2}$) and of the advection ($\chi(t) \frac{\partial S}{\partial y}$) into account.

The main features of the results obtained are as follows:

(1) The distribution of salinity in the case when the horizontal currents vary with a certain period is identical with that in the case when the sink of salinity oscillates with the corresponding period along the coast-line in the no-current field.

(2) As long as the horizontal currents are periodic, it appears that a stationary state for the distribution of salinity does not present in above case.

§ 1. Introduction

As to the theory of the diffusion of salinity in a horizontal current field, it has been already propounded by several authors. But, all these treatments were in the case of the horizontal currents of uniform velocity.

In the present paper, therefore, the author aims to deal with the case where the horizontal current velocity is in general any function of time. And, in his treatment, it is shown that, by performing the adequate coordinate

transformation in the differential equation of eddy diffusion in the horizontal current field, the equation in the no-current field is obtained. Accordingly, the solution of differential equation which generally satisfies the required conditions on the problem must be found. Recalling the mathematical theory of the conduction of heat, the purpose mentioned above will be attained.

Now, the underlying case is treated. Namely, it is assumed that the line sink of salinity exists from $y=-l$ to $y=l$ along the infinite straight coast-line bounding one end of a sea of uniform depth and of semi-infinite extent and that a horizontal current flows parallel to the coast-line. Then, applying the mathematical analysis, the author discusses in what manner the initial known distribution of salinity gives rise to the variation (with respect to x, y, and t) due to the effect of the horizontal current and the horizontal mixing.

For the sake of simplicity, the treatment in the case when a tidal current is adopted as a horizontal one is shown. (Moreover, the above treatment will be applicable to the problem on the diffusion of drifting sand in the neighbourhood of the coast-line.

§ 2. The equation of diffusion and boundary condition

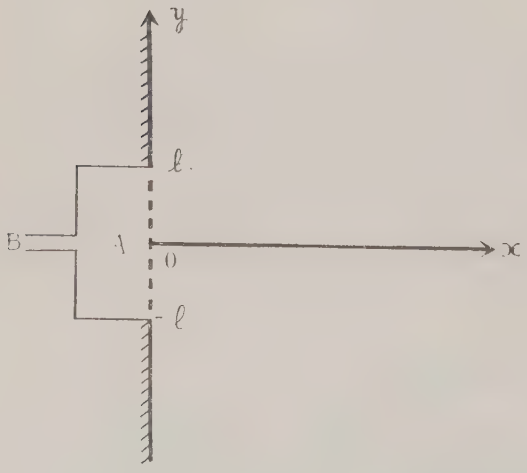

Fig. 1 A: Bay B: River

First, consider a sea of uniform depth and of semi-infinite extent whose end is bounded by an infinite straight coast-line and suppose that the line sink of salinity (in sea waters) exists from $y=-l$ to $y=l$ along the above coast-line. (See Fig. 1).

Choose the coordinate axes such that the x and y axes lie on the sea surface (where the x axis is normal to the coast-line, the y axis parallel to the one as shown by Fig. 1) and the z axis is directed vertically upwards from the sea surface.

Supposing the distribution of salinity to be non-stationary, the differential

equation governing the distribution of salinity in sea waters is

$$\frac{\partial S}{\partial t}=k_1\frac{\partial^2 S}{\partial x^2}+k_2\frac{\partial^2 S}{\partial y^2}+k_3\frac{\partial^2 S}{\partial z^2}-\chi(t)\frac{\partial S}{\partial y}, \quad \cdots\cdots(1)^*$$

where t is the time, $\chi(t)$ is the current velocity in the direction of the y axis, and k_1, k_2, and k_3 the coefficient of diffusion in the x, y, and z directions respectively. A solution of this equation can be expected to give the distribution of salinity S required. Now since the first two terms in the right-hand members in (1) represent the horizontal mixing, we may put $k_1=k_2=k$. The third term, representing the vertical mixing, is in general equal neither to k_1 nor k_2. (Accordingly, $k_1\neq k_3$.) The last term means the effect due to the consideration of the horizontal current (the so-called advection term) in the y direction.

Moreover, we may imagine that the horizontal mixing will seldom take place with the same degree of intensity as the vertical, and therefore usually the first two terms in (1) will predominate compared with the third term.

Then, the equation (1) is reduced to the following equation:

$$\frac{\partial S}{\partial t}=k\left(\frac{\partial^2 S}{\partial x^2}+\frac{\partial^2 S}{\partial y^2}\right)-\chi(t)\frac{\partial S}{\partial y}. \quad \cdots\cdots(1')$$

The initial and boundary conditions to be satisfied are as follows.

$$S\Big|_{t=0}=\sigma_0=\text{constant}, \quad \cdots\cdots(2)$$

$$\left|\frac{\partial S}{\partial x}\right|_{\substack{x=0\\ t>0}}=\psi(y)=\begin{cases}\psi_0=\text{constant} & \text{for } -l\leqq y\leqq l\\ 0 & \text{for } x>l \text{ and } x<-l\end{cases}$$

along the coast-line. $\cdots\cdots(3)$

And also, it must be satisfied that S takes the value of σ_0 at the infinite end of the sea region ($x=\infty$; $y=\pm\infty$), and $\frac{\partial S}{\partial x}$ and $\frac{\partial S}{\partial y}$ are zero at the above region.

* The equation (1) assumes that there is no vertical current. Thus, our theory cannot be applied to the regions of upwelling and sinking with respect to currents. But, if we confine ourselves to the theory of diffusion in the case when the horizontal current flows parallel to the coast-line, the equation of diffusion as given by (1) will not cause serious erros in the results. We assume, furthermore, that the effective term for the variation of the distribution of salinity due to the circumstances that the salts (in sea waters) are transported toward the sea off by the ocean wave is included in the term of the horizontal mixing in the direction of x axis.

Namely,
$$\left.\begin{aligned} &|S|_{\substack{x=\infty \\ -\infty<t<\infty}} = \sigma_0, \\ &\text{simultaneously,} \quad \left|\frac{\partial S}{\partial x}\right|_{\substack{x=\infty \\ -\infty<t<\infty}} = 0. \end{aligned}\right\} \quad \cdots\cdots(4)$$

And
$$\left.\begin{aligned} &|S|_{\substack{y=\pm\infty \\ -\infty<t<\infty}} = \sigma_0, \\ &\text{simultaneously,} \quad \left|\frac{\partial S}{\partial y}\right|_{\substack{y=\pm\infty \\ -\infty<t<\infty}} = 0. \end{aligned}\right\} \quad \cdots\cdots(5)$$

Here, it is assumed that σ_0 is the initial value of salinity and takes the constant value all over the region under consideration. Because, even if the initial value of salinity for $t<0$ is $\sigma=\sigma(x, y)$, the salinity will approach to the constant value (σ_0) all over the region by the effect due to the advection and horizontal mixing with the pass of time (as long as the line sink of salinity does not exist). Furthermore, in the above condition (3), it is assumed that the sea is always receiving a certain quantity of salinity ($\psi_0 k$) from the line sink. Therefore, the required distribution of salinity will be given by the solution of equation (1′) that satisfies the initial and boundary conditions (2), (3), (4), and (5).

§ 3. The solution of differential equation

In the present case we must solve the equation (1′) under the conditions (2), (3), (4), and (5). Divide into two parts: a steady part σ_0 and a varying part S' such that $S=\sigma_0-S'$. Then, the equation and the boundary condltions (1′), (2), (3), (4), and (5) are obviously replaced by the following formulas.

$$\frac{\partial S'}{\partial t} = k\left(\frac{\partial^2 S'}{\partial x^2} + \frac{\partial^2 S'}{\partial y^2}\right) - \chi(t)\frac{\partial S'}{\partial y} \quad \cdots\cdots(1'')$$

$$|S'|_{t=0} = 0 \quad \cdots\cdots(2')$$

$$\left|\frac{\partial S'}{\partial x}\right|_{\substack{x=0 \\ t>0}} = \psi(y) = \begin{cases} \psi_0 & \text{for} \quad -l \leqq y \leqq l \\ 0 & \text{for} \quad x > l \ \text{ and } \ x < -l. \end{cases} \quad \cdots\cdots(3')$$

$$\left.\begin{aligned} &|S'|_{\substack{x=0 \\ -\infty<t<\infty}} = 0, \\ &\text{simultaneously,} \quad \left|\frac{\partial S'}{\partial x}\right|_{\substack{x=0 \\ -\infty<t<\infty}} = 0. \end{aligned}\right\} \quad \cdots\cdots(4')$$

simultaneously,
$$\left.\begin{aligned} &|S'|_{\substack{y=\pm\infty \\ -\infty<t<\infty}} = 0, \\ &\left|\frac{\partial S'}{\partial y}\right|_{\substack{y=\pm\infty \\ -\infty<t<\infty}} = 0. \end{aligned}\right\} \quad \cdots\cdots (5')$$

Next, let us perform the following coordinate transformation in the equation (1″).

$$x = x' \quad \text{and} \quad y = y' - \int \chi(t)\, dt. \quad \cdots\cdots (6)$$

Then, (1″) is reduced to the underlying equation.

$$\frac{\partial S'}{\partial t} = k\left(\frac{\partial^2 S'}{\partial x'^2} + \frac{\partial^2 S'}{\partial y'^2}\right). \quad \cdots\cdots (1''')$$

This equation can be solved by the treatment for the case of the conduction of heat.

Now, as an example, let us adopt the case of $\chi(t) = u_0 \sin pt$,

where u_0 = the amplitude of the periodic current velocity,

$$p = \frac{2\pi}{T}. \quad (T: \text{ period})$$

Accordingly, the formula (6) becomes the following one:

$$x = x', \qquad y = y' - \frac{u_0}{p} \cos pt. \quad \cdots\cdots (7)$$

And the formula (3′), (4′), and (5′) become

$$\left|\frac{\partial S'}{\partial x'}\right|_{\substack{x'=0 \\ t>0}} = \psi\left(y' - \frac{u_0}{p}\cos pt\right) = \begin{cases} \psi_0 & \text{for} \quad -l + \dfrac{u_0}{p}\cos pt \leqq y' \leqq \dfrac{u_0}{p}\cos pt + l \\ 0 & \text{for} \quad y' > l + \dfrac{u_0}{p}\cos pt,\ y' < -l + \dfrac{u_0}{p}\cos pt \end{cases}$$

along the coast-line. $\cdots\cdots (3'')$

$$\left.\begin{aligned} &|S'|_{\substack{x'=\infty \\ -\infty<t<\infty}} = 0 \\ &\left|\frac{\partial S'}{\partial x'}\right|_{\substack{x'=\infty \\ -\infty<t<\infty}} = 0 \end{aligned}\right\} \quad \cdots\cdots (4'')$$

$$\left.\begin{aligned} &|S'|_{\substack{y'=\pm\infty \\ -\infty<t<\infty}} = 0 \\ &\left|\frac{\partial S'}{\partial y}\right|_{\substack{y'=+\infty \\ -\infty<t<\infty}} = 0 \end{aligned}\right\} \quad \cdots\cdots (5'')$$

In order to solve the equation (1‴), let S′ be expressed by Fourier's integral, then

$$S'=\frac{2}{\pi}\int_0^\infty d\alpha\int_0^\infty S'\cos\alpha\lambda\cos\alpha x'\,d\lambda.$$

By putting

$$V=\int_0^\infty S'(\lambda, y', t)\cos\alpha\lambda\,d\lambda, \quad \cdots\cdots(7)$$

we can write S' as the following form:

$$S'=\frac{2}{\pi}\int_0^\infty V(\alpha)\cos\alpha x'\,d\alpha. \quad \cdots\cdots(8)$$

And also we have

$$\frac{\partial^2 S}{\partial x'^2}=\frac{2}{\pi}\int_0^\infty d\alpha\int_0^\infty \frac{\partial^2 S'}{\partial\lambda^2}\cos\alpha x'\cos\alpha\lambda\,d\lambda.$$

But since

$$\int_0^\infty \frac{\partial^2 S'}{\partial\lambda^2}\cos\alpha\lambda\,d\lambda=\left|\frac{\partial S'}{\partial\lambda}\cos\alpha\lambda\right|_{\lambda=0}^{\lambda=\infty}+\alpha\left|S'\sin\alpha\lambda\right|_{\lambda=0}^{\lambda=\infty}-\alpha^2\int_0^\infty S'\cos\alpha\lambda\,d\lambda,$$

evaluating the values of respective terms in the above expression by the help of the conditions (3″), (4″), and (7), we obtain

$$\int_0^\infty \frac{\partial^2 S'}{\partial\lambda^2}\cos\alpha\lambda\,d\lambda=-\psi\left(y'-\frac{u_0}{p}\cos pt\right)-\alpha^2 V.$$

Therefore,

$$\frac{\partial^2 S'}{\partial x'^2}=\frac{2}{\pi}\int_0^\infty\left\{-\psi\left(y'-\frac{u_0}{p}\cos pt\right)-\alpha^2 V\right\}\cos\alpha x'\,d\alpha. \quad \cdots\cdots(9)$$

Moreover,

$$\frac{\partial^2 S'}{\partial y'^2}=\frac{2}{\pi}\int_0^\infty\frac{\partial^2 V}{\partial y'^2}\cos\alpha x'\,d\alpha \quad \cdots\cdots(10)$$

$$\frac{\partial S'}{\partial t}=\frac{2}{\pi}\int_0^\infty\frac{\partial V}{\partial t}\cos\alpha x'\,d\alpha. \quad \cdots\cdots(11)$$

Hence, substitute (9), (10), and (11) into the equation (1‴), and equate the factor of $\cos\alpha x'$, then

$$\frac{\partial V}{\partial t}=k\frac{\partial^2 V}{\partial y'^2}-k\alpha^2 V-k\psi\left(y'-\frac{u_0}{p}\cos pt\right). \quad \cdots\cdots(12)$$

Corresponding to (12), the initial and boundary conditions (2″) and (5″) are as follows:

$$V_{t=0}=0, \quad \cdots\cdots(2''')$$

$$V_{y'=\pm\infty}=0,$$

simultaneously, $$\left|\frac{\partial V}{\partial y'}\right|_{y'=\pm\infty}=0. \quad \cdots\cdots(5''')$$

In order to solve the equation (12), let V be expressed by Fourier's integral, then

$$V=\frac{1}{\pi}\int_0^\infty U d\beta \quad \cdots\cdots(13)$$

where $$U=\int_{-\infty}^{\infty} V\cos\beta(\mu-y')\,d\mu. \quad \cdots\cdots(14)$$

And also

$$\frac{\partial^2 V}{\partial y'^2}=\frac{1}{\pi}\int_0^\infty d\beta\int_{-\infty}^{\infty}\frac{\partial^2 V}{\partial\mu^2}\cos\beta(\mu-y')\,d\mu.$$

But since

$$\int_0^\infty\frac{\partial^2 V}{\partial\mu^2}\cos\beta(\mu-y')\,d\mu=\left|\frac{\partial V}{\partial\mu}\cos\beta(\mu-y')\right|_{\mu=-\infty}^{\mu=\infty}+\beta\left|V\sin\beta(\mu-y')\right|_{\mu=-\infty}^{\mu=\infty}$$
$$-\beta^2\int_{-\infty}^{\infty}V\cos\beta(\mu-y')\,d\mu,$$

evaluating the values of respective terms in the above expression by the help of the conditions (5''') and (14),

we have

$$\int_{-\infty}^{\infty}\frac{\partial^2 V}{\partial\mu^2}\cos\beta(\mu-y')\,d\mu=-\beta^2 U.$$

Accordingly,

$$\frac{\partial^2 V}{\partial y'^2}=\frac{1}{\pi}\int_0^\infty(-\beta^2)U\alpha\beta. \quad \cdots\cdots(15)$$

And also $$\frac{\partial V}{\partial t}=\frac{1}{\pi}\int_0^\infty\frac{\partial U}{\partial t}\,d\beta. \quad \cdots\cdots(16)$$

Next, we may expand $\psi(y'-\frac{u_0}{p}\cos pt)$ in Fourier's integral such as:

$$\psi\left(y'-\frac{u_0}{p}\cos pt\right)=\frac{1}{\pi}\int_0^\infty d\beta\int_{-\infty}^{\infty}\psi\left(\mu-\frac{u_0}{p}\cos pt\right)\cos\beta(\mu-y')\,d\mu$$
$$=\frac{1}{\pi}\int_0^\infty d\beta\int_{-l+\frac{u_0}{p}\cos pt}^{\frac{u_0}{p}\cos pt+l}\psi\left(\mu-\frac{u_0}{p}\cos pt\right)\cos\beta(\mu-y')\,d\mu$$

(with the aid of the formula (3'''))

$$=\frac{1}{\pi}\int_0^\infty\psi_n(\beta)\,d\beta, \quad \cdots\cdots(17)$$

where

$$\psi_n(\beta)=\frac{\psi_0}{\beta}\left[\sin\{\beta(\frac{u_0}{p}\cos pt+l-y')\}-\sin\{\beta(-l+\frac{u_0}{p}\cos pt-y')\}\right]. \quad \cdots\cdots(18)$$

Substituting the formulas (15), (16), (17), and (18) into the equation (12), we obtain

$$\frac{\partial U}{\partial t}+k(\alpha^2+\beta^2)U=-k\psi_n. \quad \cdots\cdots(19)$$

Corresponding to the equation (19), the initial condition (2″) becomes as follows:

$$U_{t=0}=0. \quad \cdots\cdots(20)$$

Solving the equation (19) under the condition (20), we get

$$U=-k\int_0^t exp\{-k(\alpha^2+\beta^2)(t-\tau)\}\psi_n(\tau)\,d\tau. \quad \cdots\cdots(21)$$

By applying (21) and (13) to (8), we have

$$S'=-\frac{2k\psi_0}{\pi^2}\int_0^t\int_0^\infty\int_0^\infty exp\{-k(\alpha^2+\beta^2)(t-\tau)\}\frac{1}{\beta}\left[\sin\{\beta(\frac{u_0}{p}\cos p\tau+l-y')\}\right.$$
$$\left.-\sin\{\beta(\frac{u_0}{p}\cos p\tau-l-y')\}\right]$$
$$\times\cos\alpha x'\,d\alpha d\beta d\tau$$
$$=-\frac{2k\psi_0}{\pi^2}\int_0^t\{\int_0^t exp\{-k\alpha^2(t-\tau)\}\cos\alpha x'\,d\alpha\int_0^\infty exp\{-k\beta^2(t-\tau)\}$$
$$\times\frac{1}{\beta}\left[\sin\{\beta(\frac{u_0}{p}\cos p\tau+l-y')\}-\sin\{\beta(\frac{u_0}{p}\cos p\tau-l-y')\}\right]d\beta\}\,d\tau.$$

But since

$$\int_0^\infty exp\{-k(t-\tau)\alpha^2\}\cos\alpha x'\,d\alpha=\frac{1}{2}\sqrt{\frac{\pi}{k(t-\tau)}}\;exp\{-\frac{x'^2}{4k(t-\tau)}\},$$

$$\int_0^\infty exp\{-k(t-\tau)\beta^2\}\frac{1}{\beta}\sin\{\beta(\frac{u_0}{p}\cos p\tau+l-y')\}\,d\beta=\frac{\pi}{2}\Phi\left[\frac{\frac{u_0}{p}\cos p\tau+l-y'}{2\sqrt{k(t-\tau)}}\right],$$

$$\int_0^\infty exp\{-k(t-\tau)\beta^2\}\frac{1}{\beta}\sin\{\beta(\frac{u_0}{p}\cos p\tau-l-y')\}\,d\beta=\frac{\pi}{2}\Phi\left[\frac{\frac{u_0}{p}\cos p\tau-l-y'}{2\sqrt{k(t-\tau)}}\right]$$

(where $\Phi(X)=\frac{2}{\sqrt{\pi}}\int_0^X exp\{-z^2\}\,dz$: the erro function),

we have

$$S'=-\frac{\psi_0}{2}\sqrt{\frac{k}{\pi}}\int_0^t\left[\Phi\left(\frac{\frac{u_0}{p}\cos p\tau+l-y'}{2\sqrt{k(t-\tau)}}\right)-\Phi\left(\frac{\frac{u_0}{p}\cos p\tau-l-y'}{2\sqrt{k(t-\tau)}}\right)\right]$$

$$\times \frac{exp\{-\frac{x'^2}{4k(t-\tau)}\}}{\sqrt{t-\tau}}\,d\tau. \quad \cdots\cdots (22)$$

Therefore,

$$S=\sigma_0-\frac{\psi_0}{2}\sqrt{\frac{k}{\pi}}\int_0^t\left\{\left[\Phi\left(\frac{\frac{u_0}{p}\cos p\tau+l-y'}{2\sqrt{k(t-\tau)}}\right)-\Phi\left(\frac{\frac{u_0}{p}\cos p\tau-l-y'}{2\sqrt{k(t-\tau)}}\right)\right]\right.$$
$$\left.\times\frac{exp\{-\frac{x'^2}{4k(t-\tau)}\}}{\sqrt{t-\tau}}\right\}d\tau. \quad \cdots\cdots (23)$$

From the formula (23) or (24), it is seen that as to the variation of salinity in the direction of y axis parallel to the coast-line, it depends upon the following terms involving y and t as variable numbers:

$$\Phi\left(\frac{\frac{u_0}{p}\cos p\tau+l-y'}{2\sqrt{k(t-\tau)}}\right) \quad \text{and} \quad \Phi\left(\frac{\frac{u_0}{p}\cos p\tau-l-y'}{2\sqrt{k(t-\tau)}}\right).$$

And also these functions Φ are oscillatory in respect of time. Therefore, the mode of the distribution of salinity is always in the non-stationary state. Accordingly, it obviously appears that the distribution of salinity ($=S$) cannot be able to attain to the stationary state with $t\to\infty$.

The reasons are as follows. The field of the distribution of salinity does not enable us to make the stationary state because the horizontal current always varies with a certain period. Furthermore, by performing the coordinate transformation (6) into the equation (1″), (1″) is reduced to the equation (1‴) which is considered as the equation in the no-current field. On the other hand, the line sink of salinity existing from $y=-l$ to $y=l$ along the coast-line is replaced in the region from $y=-l+\frac{u_0}{p}\cos pt$ to $y=\frac{u_0}{p}\cos pt+l$. And yet, it oscillates with the period corresponding to the current's period. Namely, the distribution of salinity in the case when the horizontal currents vary with a certain period is identical with that in the case when the sink of salinity oscillates with the corresponding period in the region of $-l+\frac{u_0}{p}\cos pt \leqq y \leqq \frac{u_0}{p}\cos pt+l$ along the coast-line in the no-current field.

Next, when $l\to\infty$ in the formula (23), we have the following formula:

$$S=\sigma_0-\psi_0\sqrt{\frac{k}{\pi}}\int_0^t exp\{-\frac{x'^2}{4k(t-\tau)}\}\frac{1}{\sqrt{t-\tau}}\,d\tau. \quad \cdots\cdots (24)$$

This is identical with the distribution of salinity in the case when the infinitely long line sink exists all over the coast-line under consideration.

(And, the formula (24) is identical with the solution already obtained in the theory of conduction of heat.) In the case when the horizontal currents are

the two dimensional flow, the equation of eddy diffusion is as follows:

$$\frac{\partial S}{\partial t}=k\left(\frac{\partial^2 S}{\partial x^2}+\frac{\partial^2 S}{\partial y^2}\right)-\chi_1(t)\frac{\partial S}{\partial x}-\chi_2(t)\frac{\partial S}{\partial y}. \quad \cdots\cdots(25)$$

Where $\chi_1(t)$ and $\chi_2(t)$ are the components of current velocity in the direction of the x— and y— axes.

Now, performing the following coordinate transformation:

$$x=x'-\int\chi_1(t)\,dt \quad \text{and} \quad y=y'-\int\chi_2(t)\,dt$$

into the equation (25), the equation (25) becomes the equation in the no-current field:

$$\frac{\partial S}{\partial t}=k\left(\frac{\partial^2 S}{\partial x'^2}+\frac{\partial^2 S}{\partial y'^2}\right).$$

In above case, in addition to the boundary condition $\left(\left|\frac{\partial S}{\partial x}\right|_{x=0}=\psi(y)\right)$ along the coast-line previously given in our case, by the consideration of the following condition: $S_{x=0}=f(y)$, the required solution can be instinctly determined. The reason is as follows. By performing the following coordinate transformation: $x=x'-\int\chi_1(t)\,dt$, the mode of the variation of the current velocity $\chi_1(t)$ is replaced by the fact that the intensity of the line sink varies toward the direction of the x axis. Accordingly, we must inevitably supplement the condition due to the consideration of the fact mentioned above.

The reason that the treatment in our case previously mentioned is restricted to two dimensional one is as follows: As the density of waters supplied by the line sink is smaller than that of sea waters, the waters (supplied by the line sink) are spread over only the horizontal direction in the upper layer of the ocean and they do not comparatively mix with the sea waters in the vertical direction.

The theoretical results already treated may be adequate to the underlying case. For example, as shown by Fig. 1, the waters of the river (B) flowing into the inner part of the bay (A) fully mix with the sea waters in the bay, and consequently the salinity of sea waters in the bay is enabled us to reduce and the salts (of sea waters in the bay) are transported from the mouth of the bay (A) toward the sea off.

In the case where the problem of the diffusion of a drifting sand is treated, the terms of the vertical component in the equation of eddy diffusion must be considered.
Accordingly, the equation of eddy diffusion is as follows.

$$\frac{\partial S}{\partial t}=k\left(\frac{\partial^2 S}{\partial x^2}+\frac{\partial^2 S}{\partial y^2}\right)+k'\frac{\partial^2 S}{\partial z^2}-\chi_1(t)\frac{\partial S}{\partial x}-\chi_2(t)\frac{\partial S}{\partial y}-w_0\frac{\partial S}{\partial z}, \quad \cdots\cdots(26)$$

where S means the density of the drifting sands, w_0 the sinking velocity of the particle (of the drifting sands).

In this case, performing the coordinate transformation (mentioned above) into the equation (26), we have the following equation:

$$\frac{\partial S}{\partial t}=k\left(\frac{\partial^2 S}{\partial x'^2}+\frac{\partial^2 S}{\partial y'^2}\right)+k'\frac{\partial^2 S}{\partial z^2}-w_0\frac{\partial S}{\partial z}. \quad \cdots\cdots (27)$$

Now, putting $S=exp\{-w_0 t\}\Phi(x', y', z, t)$ in (27), the equation (27) becomes

$$\frac{\partial \Phi}{\partial t}=k\left(\frac{\partial^2 \Phi}{\partial x'^2}+\frac{\partial^2 \Phi}{\partial y'^2}\right)+k'\frac{\partial^2 \Phi}{\partial z^2}. \quad \cdots\cdots (28)$$

Recalling the mathematical theory of the conduction of heat, we are able to obtain the solution of this equation.

Finally, I wish to express my hearty thanks to Prf. M. Tauchi who gave me this problem, and wish to express my thanks to the Ministry of Education by which the present investigation has undergone the financial aid.

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ON THE RELATION BETWEEN THE VARIATION OF THE IMPORTANT FISHERIES CONDITIONS AND THE OCEANOGRAPHICAL CONDITIONS IN THE ADJACENT WATERS OF JAPAN 1.

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It is wellknown that the fluctuation of the oceanographical conditions has the profound influence upon the recruitment, survival and mortality, growth, migration, fishing grounds and the catches of important fishes, and consequently results to their natural fluctuation. However hitherto, owing to the lack of the basic materials and the complexity of the problems, the researches on those interrelationships were very scarce. The author has intended to attack and solve those difficult problems as far as he can at present.

Now, let us consider the yield of a species of fish per unit fishing effort N, the abundance of the fish P, the recruitment of that fish R, and their corresponding environmental factors for P and R as Q and Q_o respectively.

Then $N=f_1(P,Q)=f_2(R,Q)=f_3(Q,Q_o)$.

Accordingly we may consider that in general the environmental (oceanographical and meteorological) conditions have the dominant influence upon the recruitment of each year and the succeeding yields of those fishes on their migratory routes. It seems that the factors such as water temperature, currents, constituents of the sea water, plankton etc. may give influences on the spawning, development and survival of youngs, migration and ultimately to the fluctuation of the fish abundance.

1. The Spring Herring Yield of Hokkaido Correlated with the Sea Conditions

As for the fluctuation of the spring herring fishery of Hokkaido the studies by M. Kurakami [1], T. Kawana [2], S. Sato [3] etc. have already shown the relation between the yield of herring and its recruitment (brood) with the sun-spot number and the sea conditions i. e. the rich years correspond to the favourable intensity of the Tsushima Current.

(i) Comparing the fluctuation of the herring yield and its recruitment shown by the above studies to the hydrographical fluctuation, the author found a remarkable correlation between the poor catch years of the Hokkaidō herring and the abnormal cold (abnormal low sea temperature) as shown in the Table 1. (See Fig. 1).

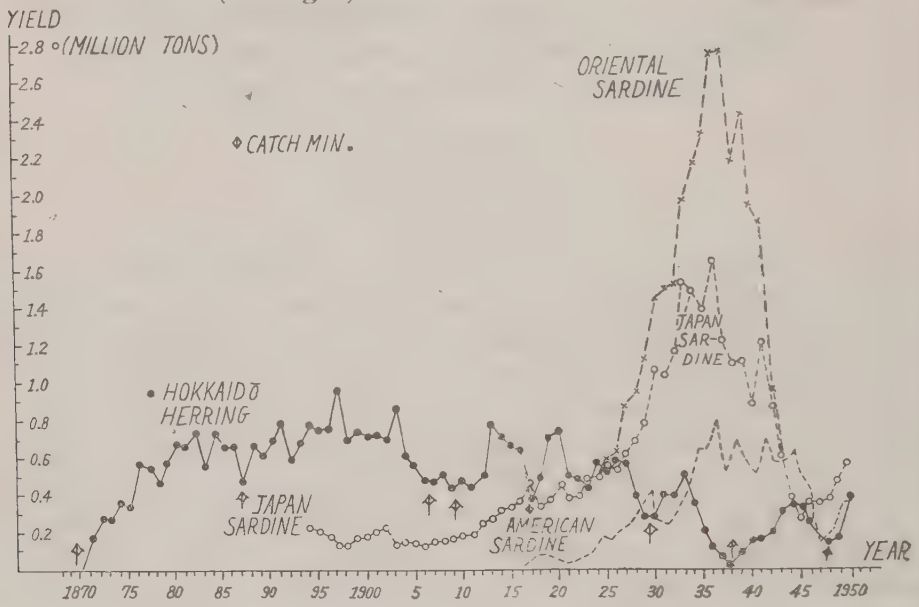


Fig. 1. Yields of herring and sardine in the statistical years.

Table 1.

The abnormal Cold year		Interval Years	The Poor catch year of Hokkaidō Herring
(Bad Harvest)	1866	4	1870
〃	(1869)	4	(1873)
〃	(1884)	3	1887
〃	1902	4	1906, 1907
〃	1905	4	1909
〃	1913	4	1917
〃	1926	4	1930
〃	1934, (1935)	4	1938(1939)
〃	1944, (1945)	4	1948

Therefore, we have the bad years of the Hokkaidō spring herring fishery on every four (or three) years after the abnormal cold year (the year of the bad harvest of rice crop on the land), which means that the bad breeding in the year of the extreme low water temperature (the weak year of warm current) resulted to the scacity of the dominant adults migrated as the fourth (or third) aged herring.

(ii) Corresponding to the anomalous years of Kuroshio (the rich years of skipjack in the seas off the coast of the Wakayama and Mie Prefecture presented westerly coastal current near C. Sionomisaki and the strong onshore current near Sima Penninsula), the spring herring fishery in Hokkaidō has shown the extremely bad years (poor catch in general) as we see in 1937–39, 1917–18, and 1906–07.[4]

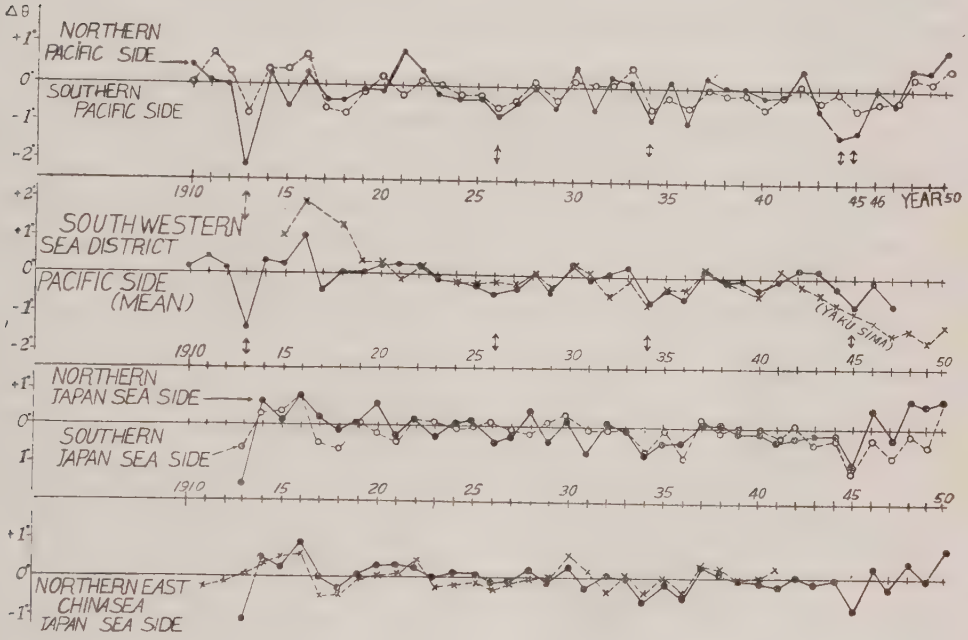


Fig. 2. Anomaly of coastal water temperature (Year Mean) $\Delta\theta$.

(iii) The trends of the yield variation of herring are appeared to run conversely to that of sardine (see Fig. 1)* In the years 1937 and 1938 (the strongly north-going warm current period) against the richest yield of Hokkaidō sardine the herring yields were the poorest.

In the years 1944 and 1945 (of the lowest water temperature) the complete decline of the sardine catch corresponds to the somewhat restoration of the herring fishery.

(iv) The historical fluctuation of the European herring fishery as explained by Otto Pettersson[5] coincides well with the phase of the fluctuation of the oriental herring fishery.[2][6] (See Table 2).

* Also the california sardine yield (abundant in 1934–44) shows nearly inverse trend to that of the oriental herring.

Table 2.

European herring rich period	1660–80,	1752–1810,	1876–97.
Hokkaidō herring rich period	(no record),	1748–76.	
		Hōen, Hōreki An'ei.	1877–1905,
		Max, Meiwa 1764–71	Meidi 10–38
Hokkaidō herring poor period	(〃)	1777–*83*–91 (Min.1784, Tenmei 4,)	1906–43

2. The Relation Between the Fluctuation of the "Iwasi" (Sardine) Fishery and the Oceanographical Conditions

(i) Hitherto the sardine fishing areas extend comparatively to northern waters in good catch years and shrink to the south in bad catch years. (On the contrary, in the case of the herring fishery it shrinks to the

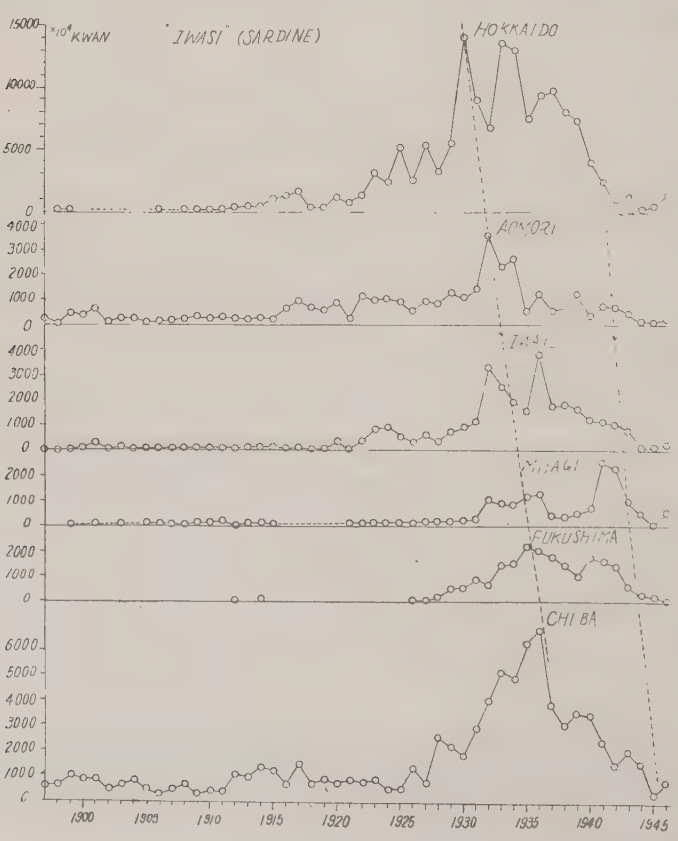


Fig. 3. The yeald of sardine from North (Hokkaidō) to South (Chiba Pref.) in the NE-Japan sea region and the Lags of Its Max, and Min.

north in bad years and extends to the south in good years.) (See Fig. 3).

(ii) Inspecting in the secular variation of the coastal water temperature along the Japan Is. (Fig. 2 & Tab. 3) it shows a general trend of decrease from the beginning of the Taishō era (1914–15) to the years 1944–45 (at its minimum) and then increase year by year from 1946 to 1950, especially in 1949 and 1950 considerably warmer, corresponding to the anomalous good fishing conditions of some important fishes such as skipjack and pacific saury etc.

The anomalous conditions of Kuroshio due to the appearance of cold water-mass off C. Sionomisaki[4)7)8)] has begun from 1934–35 and indicated its most conspicuous intensity during 1937–41, and then decaying gradually to 1945. The maximum prosperity of the cold water mass occurred in the spring of 1938. By this reason (and by that in § 3) it is considered that the feeble larvae of sardine spawned in the southern coastal water-mass off Kyūshū drift in the Kuroshio Current, and on its journey carrying out to the southern warm (saline) water area off C. Sionomisaki, most of them should be destroyed as suggested by Z. Nakai[9)].

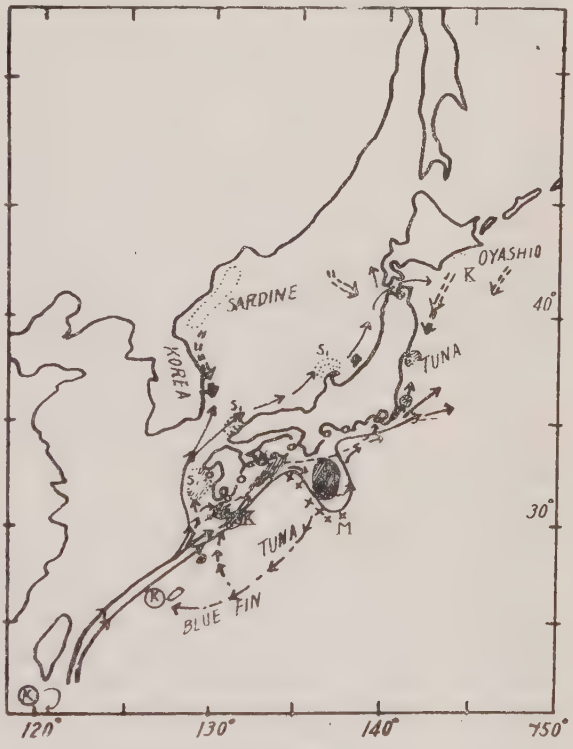


Fig. 4. Some illustrations for sardine and bluefin tuna fishing grounds.

As its consequence the important cause of the succeeding decline of the oriental sardine yield may be found in the above-mentioned hydrographical variation. The effect of the anomalous Kuroshio upon the sardine resource caused by conspicuous cold water mainly in the years 1937–45 (and along the pacific coast to 1947), toge-

Table 3. (A) Anomaly of annual mean water temp. (°C) on the coast of Northern Pacific side.

Location		Tisima Etorohu Atoiya C.	Hokkaido C. Notori	Hokkaido C. Nosyappu	Hokkaido C. Erimo	Hokkaido C. Siokubi	Aomori C. Siriya	Iwate C. Todo	Miyagi Enosima	Hukusima C. Sioya	Tiba Tyosi	Mean Pacific N. Coast
Year	Era	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}	a_3–a_{10}
1910	Meidi 43	—	—	—	—	—	—	—	+0.5	—	—	+0.5
11	44	—	—	—	—	—	—	—	+0.2	—	—	+0.2
12	45	—	—	—	—	—	—	—	0	—	—	0
13	Taisyo 2	—	—	−3.1	−1.7	−2.9	−2.4	—	−1.7	−0.4	—	−2.1
14	3	—	—	0.0	+0.2	+0.1	+0.3	—	+0.6	+0.4	—	+0.3
15	4	—	—	−1.5	−1.1	−0.2	+0.3	—	+0.2	−0.8	—	−0.5
16	5	—	—	0.0	+0.1	+0.5	+0.4	—	+0.8	+0.7	—	+0.4
17	6	—	—	−0.6	−0.4	+0.3	−0.4	—	+0.5	−1.1	−0.2	−0.3
18	7	—	—	+0.1	−0.3	−0.5	0.0	—	−0.3	−1.2	−0.0	−0.3
19	8	−0.2	+0.2	−0.5	−0.4	+0.3	−0.1	−0.2	+0.2	−0.4	+0.2	−0.1
20	9	+0.3	−0.2	+0.2	+0.3	−0.8	−0.2	−0.7	+0.1	−0.3	+0.8	−0.1
21	10	+0.2	−0.3	−0.0	+0.4	+0.2	+0.1	−0.0	+2.2	+2.3	+1.5	+1.0
22	11	−0.2	0.0	+0.3	−0.1	−0.2	+0.3	−0.3	+1.0	+0.9	+1.5	+0.5
23	12	+0.4	0.0	+0.1	0.0	+0.4	+0.1	−0.7	−0.3	−0.5	+0.3	−0.1
24	13	+0.4	0.0	−0.4	−0.4	−0.4	+0.3	−0.8	−0.4	+0.3	+0.1	−0.2
25	14	+0.3	+0.9	+0.5	−0.2	−0.5	−0.2	−0.8	−0.4	−0.2	+0.2	−0.2
26	15	−2.0	−0.6	−0.5	−1.7	+0.1	+0.2	+0.2	−0.7	−1.1	−1.1	−0.7
27	Syowa 2	0.0	+0.9	+0.1	−0.2	−0.1	−0.3	−0.1	−0.8	−0.9	−0.2	−0.4
28	3	+1.1	+1.1	+0.3	+1.0	+0.4	+0.2	+0.4	−0.6	−0.5	−0.7	+0.1
29	4	+0.0	−0.1	−0.5	0.0	−0.9	−0.1	−0.5	−0.5	−0.8	−0.5	−0.5
30	5	+0.5	−0.1	−0.1	+1.1	+0.1	+0.3	+0.5	0.0	+1.1	+1.2	+0.6
31	6	−0.8	−1.0	−0.2	−0.2	−0.9	−0.2	−0.5	−1.0	−0.8	−0.1	−0.5
32	7	+0.1	0.0	+0.4	+0.1	+0.6	+0.5	+0.8	+0.1	0.0	+0.1	+0.4
33	8	+1.1	+0.5	+0.2	+0.2	+0.6	−0.3	−0.1	+0.1	+0.9	+0.6	+0.3
34	9	+0.6	−0.7	+0.1	−0.2	−0.5	−0.9	−0.7	−1.7	−0.7	−0.5	−0.7
35	10	+1.1	0.0	+0.2	−0.1	+0.6	−0.1	+0.1	−1.0	−0.8	−0.9	−0.3
36	11	+1.5	+0.1	−0.2	−0.6	0.0	−0.1	−0.3	−1.2	−1.5	−1.5	−0.8
37	12	+1.7	+0.3	+0.4	+1.1	+0.8	+0.3	+0.6	−0.2	−0.0	+0.1	+0.4
38	13	+0.7	+0.6	+0.7	+1.4	+0.5	+0.4	−0.5	−1.1	−0.2	+0.2	+0.2
39	14	+0.0	0.0	+0.4	+0.1	−0.1	+0.0	+0.3	+0.1	+0.3	+0.4	+0.2
40	15	+0.4	+0.3	+0.4	+0.2	+0.3	+0.1	−0.1	−0.4	−0.5	+0.0	0.0
41	16	−3.3	−0.7	+0.1	−0.4	+0.2	−0.1	+0.3	−0.3	−0.2	−0.1	−0.1
42	17	−2.4	−0.4	+0.4	−0.1	+0.6	+0.4	+0.3	+1.0	+1.5	+1.1	+0.7
43	18	−2.1	—	+0.2	+0.5	−0.5	−0.5	−1.0	−1.2	−0.7	−0.4	−0.5
44	19	−3.0	—	+0.0	−0.5	−0.5	−0.6	−1.1	−3.1	−1.4	−1.2	−1.1
45	20	—	—	−0.4	+0.1	−1.5	−1.5	−1.2	—	−1.6	−1.1	−1.0
46	21	—	—	+0.2	+0.6	+0.2	—	+0.3	—	0.0	—	+0.3
47	22	—	—	−0.3	−0.1	+0.1	—	−0.6	—	−0.5	—	−0.2
48	23	—	—	+1.0	—	+0.4	—	+0.2	—	+0.6	—	+0.6
49	24	—	—	+0.5	—	+0.7	—	+0.4	—	+0.3	—	+0.5
50	25	—	—	+0.8	—	+1.0	—	+0.6	—	+1.5	—	+1.0
Statistical Year		26	24	38	35	38	33	32	35	38	29	

Table 3. (B) Anomaly of annual mean water temp. (°C) on the coast of Southern Pacific side.

Location			Tiba Pref. Katuura	Tiba C. Nozima	Idu Mikomoto Is.	Wakayama Sionomisaki	Kōti Pref. C. Muroto	Kōti Pref. C. Asizuri	Miyazaki Utimi	Miyazaki C. Kurasaki	Kagosima C. Sata	S. Pacific Coast
Year	Era		b_1	b_2	b_3	b_5	b_6	b_7	b_{10}	b_{11}	b_{13}	Mean
1900	Meidi	33	—	—	—	+0.7	—	—	—	—	—	+0.7
1		34	—	—	—	+1.2	—	—	—	—	—	+1.2
2		35	—	—	—	+0.9	—	—	—	—	—	+0.9
3		36	—	—	—	+0.6	—	—	—	—	—	+0.6
4		37	—	—	—	+0.9	—	—	—	—	—	+0.9
5		38	—	—	—	(+2.5)	—	—	—	—	—	(+2.5)
6		39	—	—	—	—	—	—	—	—	—	—
7		40	—	—	—	—	—	—	—	—	—	—
8		41	—	—	—	—	—	—	—	—	—	—
9		42	—	—	—	—	—	—	—	—	—	—
10		43	—	—	—	−0.1	—	—	—	—	—	−0.1
11		44	—	—	—	+0.8	—	—	—	—	—	+0.8
12		45	—	—	—	+0.4	—	—	—	—	—	+0.4
13	Taisyō	2	—	−0.1	−1.0	−0.9	—	—	—	—	—	−0.7
14		3	—	+0.2	−0.2	+1.1	—	—	—	—	—	+0.4
15		4	—	+0.4	+0.2	+0.9	—	—	—	—	—	+0.5
16		5	—	+0.5	+0.4	+1.5	—	—	—	—	—	+0.8
17		6	—	−0.5	−0.2	−0.7	—	—	—	—	—	−0.5
18		7	—	+0.3	−0.1	−2.3	—	—	—	—	—	−0.7
19		8	+0.3	+0.2	+0.6	−1.2	−0.3	−0.7	−0.3	+0.5	+0.2	−0.1
20		9	+1.0	+0.5	+0.2	−0.9	+0.3	−0.1	+0.2	+0.8	+0.3	+0.3
21		10	−0.0	−0.2	−0.8	−0.7	−0.6	−0.2	+0.2	+0.3	−0.1	−0.2
22		11	+0.3	+0.4	−0.4	+0.2	+0.4	−0.3	+0.0	+0.9	+0.4	+0.2
23		12	+0.9	+0.4	−0.1	+0.2	+0.1	−0.1	−0.2	+0.2	−0.5	+0.1
24		13	−0.3	−0.1	−0.7	+0.1	−0.1	+0.2	−0.3	−0.5	−0.4	−0.2
25		14	−0.3	−0.1	−0.2	−1.0	−0.2	+0.1	−0.1	+0.1	+0.2	−0.2
26		15	−0.6	−0.1	−0.5	−1.5	−0.6	−0.7	−0.5	−0.2	−0.2	−0.5
27	Syōwa	2	−0.7	−0.2	−0.7	−0.5	−0.2	−0.4	−0.3	−0.0	+0.2	−0.3
28		3	+0.5	+0.5	−0.2	−0.8	+0.5	+0.3	+0.2	+0.4	+0.3	+0.2
29		4	−0.2	−0.0	−0.8	−1.3	+0.1	+0.6	+0.1	−0.4	−0.7	−0.3
30		5	+0.4	+0.7	−0.3	+0.3	+0.5	+0.5	+0.5	+0.1	+0.1	+0.3
31		6	+0.2	+0.6	−0.6	+1.0	+0.3	+0.3	+0.1	−0.4	+0.4	+0.2
32		7	+0.6	+0.2	−0.7	+1.3	−0.3	±0.0	+0.1	+0.4	−0.1	+0.2
33		8	+2.3	+0.5	+0.4	+1.9	+0.4	+0.4	+0.3	+0.1	+0.1	+0.7
34		9	−1.0	−1.0	−0.0	−0.1	−0.6	−0.0	−0.4	−0.4	−0.8	−0 5
35		10	−1.5	−0.7	+0.7	+0.5	−0.1	−0.1	+0.1	+0.1	+0.2	−0.1
36		11	−1.0	−1.0	−0.1	+0.1	−0.7	−0.3	−0.3	−0.4	−0.2	−0.4
37		12	−0.6	−0.5	+1.1	+0.8	−1.0	+0.1	+0.6	+0.4	+0.6	+0.2
38		13	−0.1	+0.1	+0.8	−0.4	−0.7	0.0	−0.0	+0.0	+0.2	0.0
39		14	−0.3	−0.4	+0.9	−0.2	−0.1	−0.1	+0.0	+0.1	−0.2	0.0
40		15	−0.3	−0.2	+0.7	−0.7	−0.3	−0.4	−0.9	−0.8	−0.3	−0.4
41		16	+0.4	−0.5	+1.0	+0.4	+0.0	+0.2	−0.6	−1.1	+0.0	0.0
42		17	+1.0	−0.1	+1.4	+0.7	+0.2	+0.2	−0.0	−0.9	+0.2	+0.3
43		18	+0.5	+0.1	+0.5	−0.0	−0.0	+0.0	−0.4	−0.6	−0.6	−0.1
44		19	+0.5	−0.2	—	+0.9	−0.1	−0.0	—	−0.1	+0.2	+0.2
45		20	+0.4	−0.3	—	+0.4	−1.3	−0.3	—	−0.4	−0.4	−0.3
46		21	+1.4	+0.1	—	+0.2	−0.8	—	—	0.0	—	−0.2
47		22	−0.8	−0.1	—	−0.0	−0.1	—	—	−0.4	—	−0.2
48		23	−0.2	+0.8	—	+0.4	0.0	—	—	+0.3	—	+0.3
49		24	+0.1	+0.6	—	+0.4	−0.1	—	—	+0.1	—	+0.2
50		25	+0.2	+0.5	—	+0.6	+0.5	—	—	+0.3	—	+0.5
Statistical Year			32	38	31	47	32	27	25	32	27	

Table 3. (C) Anomaly of annual mean water temp. (C°) on the South-Western Sea coast.

Location		Kagosima Yaku Is.	Riukiu Ie Is.	Riukiu Tuken Is.	Formosa Hōkasyo Is.	Formosa Goarampii	SW-sea District c_1–c_5	Pacific Side a_3–c_5
Year	Era	c_1	c_2	c_3	c_4	c_5	Mean	Mean
1915	Taisyo 4	—	—	—	+ 0.7	(+1.3)	+ 1.0	+ 0.3
16	5	—	—	—	+ 0.7	(+3.4)	+ 2.0	+ 1.1
17	6	—	—	—	—	—	—	— 0.4
18	7	—	—	—	+ 1.5	+ 1.3	+ 1.4	+ 0.1
19	8	+ 0.5	+ 0.1	+ 0.1	+ 0.4	+ 0.8	+ 0.4	+ 0.1
20	9	+ 1.0	— 0.3	— 0.1	+ 0.9	+ 0.7	+ 0.4	+ 0.2
21	10	+ 0.4	— 0.3	— 0.5	— 0.0	+ 0.3	0.0	+ 0.3
22	11	+ 0.7	+ 0.1	— 0.5	+ 0.1	+ 0.6	+ 0.2	+ 0.3
23	12	— 0.0	+ 1.1	— 1.1	0.0	+ 0.3	+ 0.1	0.0
24	13	— 0.4	+ 0.1	— 0.2	+ 0.1	+ 0.3	0.0	— 0.1
25	14	— 0.6	— 0.8	— 0.4	— 0.2	+ 0.4	— 0.3	— 0.2
26	15	— 0.8	+ 0.1	— 0.2	— 0.2	+ 0.4	— 0.1	— 0.4
27	Syowa 2	— 0.9	— 0.2	— 0.3	— 0.4	+ 0.6	— 0.2	— 0.3
28	3	— 0.1	— 0.2	— 0.2	+ 0.4	+ 0.7	+ 0.1	+ 0.1
29	4	— 0.3	— 0.2	— 0.1	— 0.7	+ 0.2	— 0.2	— 0.3
30	5	+ 0.2	+ 0.8	+ 0.8	— 0.3	+ 0.3	+ 0.4	+ 0.4
31	6	+ 0.2	+ 0.7	+ 0.8	+ 0.6	— 0.2	+ 0.2	0.0
32	7	— 0.2	— 0.4	— 0.3	— 0.0	— 1.0	— 0.4	+ 0.1
33	8	+ 0.3	+ 0.1	+ 0.2	+ 0.8	— 1.3	0.0	+ 0.3
34	9	— 0.0	— 0.1	— 0.6	— 0.1	— 2.3	— 0.6	— 0.6
35	10	+ 0.2	— 0.2	— 0.1	— 0.2	— 0.5	— 0.2	— 0.2
36	11	— 0.3	+ 0.1	— 0.3	— 0.2	— 0.6	— 0.3	— 0.5
37	12	+ 0.6	+ 0.3	+ 0.6	+ 0.1	0.0	+ 0.3	+ 0.3
38	13	+ 0.1	+ 0.2	+ 0.5	+ 0.3	— 1.0	0.0	+ 0.1
39	14	— 0.4	— 0.6	— 0.1	— 0.4	— 0.8	— 0.3	0.0
40	15	+ 0.4	— 0.4	— 0.3	— 0.5	— 0.6	— 0.4	— 0.3
41	16	+ 0.2	+ 0.1	+ 0.6	— 0.0	+ 0.4	+ 0.3	+ 0.1
42	17	+ 0.4	— 0.2	+ 0.7	+ 0.1	+ 0.1	— 0.1	+ 0.3
43	18	— 0.3	— 0.1	— 0.3	— 0.5	—	— 0.3	+ 0.3
44	19	— 0.6	— 0.4	+ 0.1	+ 0.3	—	— 0.1	— 0.1
45	20	— 0.8	—	—	(−0.2)	—	−(0.8)	— 0.7
46	21	—	—	—	—	—	0.0	0.0
47	22	— 1.5	—	—	—	—	(−1.5)	— 0.6
48	23	— 1.4	—	—	—	—	(−1.4)	—
49	24	— 1.7	—	—	—	—	(−1.7)	—
50	25	— 1.3	—	—	—	—	(−1.3)	—
Statistical Year		31	26	26	30	27	31	33

Table 3. (D) Anomaly of annual mean water temp (°C) on the Northern coast of Japan Sea side.

Location		Saghalin C Nisinotoro	Hokkaidō Osidomari	Hokkaidō Yanziri Is.	Hokkaidō C. Kamui	Hokkaidō C. Inaho	Hokkaidō C. Sirakami	Akita Pref. C. Nyūdō	Yamagata Tobisima	Niigata C. Hime	Isikawa C. Rokugō	d_1 — d_{10}
Year	Era	d_1	d_2	d_3	d_4	d_5	d_6	d_7	d_8	d_9	d_{10}	Mean
1913	Taisyō 2	−0.5	—	—	—	−2.7	−1.8	−1.0	—	−1.9	−1.3	−1.5
14	3	−0.1	—	—	—	−0.1	+0.9	+2.0	—	+1.1	+0.5	+0.7
15	4	+0.4	—	—	—	−0.4	−0.3	+0.7	—	+0.6	−0.1	+0.2
16	5	+2.9	—	—	—	−0.3	−0.0	+0.8	—	+0.9	—	+0.9
17	6	+1.7	—	—	—	−0.1	−0.1	+0.8	—	+0.2	−0.5	+0.3
18	7	+2.0	—	—	—	−1.1	+0.2	−0.2	—	−0.2	−0.5	0.0
19	8	+0.9	0.0	+0.3	−0.1	−0.5	+0.3	+0.6	−0.4	−0.5	+0.4	+0.1
20	9	+2.4	+0.3	+0.9	+0.3	+0.1	+0.6	+0.9	+0.7	+0.5	+0.1	+0.7
21	10	−0.7	−0.1	+0.3	0.0	−0.5	0.0	−0.1	+0·2	0.0	−1.1	−0.2
22	11	−0.5	−0.2	+0.5	+0.2	+0.5	+0.2	−0.1	+1.0	+1.0	+0.0	+0.3
23	12	−0.2	−0.7	+0.3	+0.5	−0.4	−0.8	−0.2	+0.5	+0.3	−1.0	−0.2
24	13	−1.1	+0.7	+1.4	+0.4	−0.1	−0.6	+0.3	+0.8	+0.6	−1.2	+0.1
25	14	−0.0	+1.3	+1.0	+0.2	+1.6	−0.4	−0.6	+0.6	+0.5	−0.8	+0.2
26	15	−0.1	+0.3	+0.2	−0.5	+1.2	−1.0	−1.5	−0.8	+0.3	−0.6	−0.3
27	Syōwa 2	−0.7	+0.9	+0.2	−0.2	+0.9	−1.3	−1.2	−0.7	−0.5	+0.5	−0.2
28	3	+0 7	+1.2	+1.2	+0.5	+1.1	−0.5	−1.1	+0.2	+0.4	+1.1	+0.5
29	4	−0.8	−0.5	−0.2	+0.0	+0.4	−1.5	+0.0	+0.0	+0.5	+0.4	−0.3
30	5	−0.7	0.0	−0.0	+0.2	+0.4	−1.0	+0.3	+0.6	+1.3	+1.0	+0.2
31	6	−1.8	−0.5	−0.9	+0.6	−0.8	−0.1	−0.8	−1.6	±0.0	−0.2	−0.6
32	7	−0.5	−0.2	−0.2	+0.7	+0.6	+0.5	+0.5	−1.2	+1.0	+0.4	+0.2
33	8	−0.4	−0.3	−0.3	+0.1	−0.1	−0.5	+0.9	−0.6	+0.8	+0.8	+0.0
34	9	−0.3	−0.5	−0.9	−0.3	−0.7	−0.3	−0.3	−1.3	−1.4	−0.5	−0.7
35	10	−0.7	−0.5	−0.6	−0.2	0.0	+0.7	+0.4	−0.6	−1.2	+0.2	−0.3
36	11	−0.3	−0.5	−0.7	−0.0	−0.3	+0.6	+0.5	−0.3	−2.0	−0.6	−0.3
37	12	−0.5	+0.1	−0.4	−0.1	+0.3	+1.4	+0.8	+0.5	−1.1	+0.9	+0.2
38	13	+0.4	+0.6	+0.3	+0.3	+0.3	+1.0	−0.2	+0.4	−1.2	−0.0	+0.2
39	14	−0.3	−0.1	−0.4	−0.3	−0.1	+1.0	+0.1	+0.7	−1.0	+0.2	0.0
40	15	−0.8	−0.1	−0.3	+0.1	−0.3	+0.9	−0.0	+0.2	−0.2	+0.2	0.0
41	16	−0.7	−0.4	−0.7	−0.5	−0.2	+0.8	−0.4	+0.2	−0.4	−0.3	−0.2
42	17	−1.1	−0.4	−0.9	−0.5	+0.2	+0.9	+0.1	+0.4	+0.1	+0.5	−0.1
43	18	−0.9	−0.1	+0.2	−0.4	+0.6	+0.5	+0.1	+0.2	−0.3	0.0	0.0
44	19	−1.7	−0.1	−0.7	−0.1	+0.2	+0.1	+0.1	−0.2	−0.6	+0.3	−0.3
45	20	(−0.5)	−0.0	(−1.0)	−0.3	−1.0	−1.0	−0.7	−1.7	−2.2	−0.5	−0.9
46	21	—	(+1.1)	—	+1.0	+1.3	(+0.8)	+0.3	−1.2	−0.2	+1.0	+0.4
47	22	—	+0.2	+0.2	+0.1	+0.2	−0.2	−0.9	+0.1	−0.5	−0.5	−0.1
48	23	—	+1.2	+1.4	—	+0.8	+0.8	+0.0	+1.3	+0.7	+0.2	+0.8
49	24	—	(+0.8)	+0.5	—	+0.5	+1.0	+0.1	+0.7	+0.4	+0.6	+0.6
50	25	—	—	−0.7	—	(+0.6)	(+1.5)	+0.8	(+1.5)	(+0.8)	+0.7	+0.7
Statistical Year		33	31	31	29	38	38	35	29	38	35	38

Table 3. (E) Anomaly of annual mean water temp. (°C)
On the Southern coast of Japan Sea side.

Location			Kyōto Pref. C. Kyōga-misaki	Idumo-Hinomisaki	Simane Hamada	Yamaguti Misima	Yamaguti Tunozima Lt. hs.	Yamaguti Hutaizima	Tusima Channel Okinosima	Tusima Channel Misima	Tusima Kōsaki	Goto Is. Osezaki	e_1 — e_{13}
Year	Era		e_1	e_3	e_5	e_6	e_7	e_9	e_{10}	e_{11}	e_{12}	e_{13}	Mean
1913	Taisyō	2	—	−1.0	—	—	−1.1	—	—	−0.3	—	+0.0	−0.6
14		3	—	−0.1	—	+0.7	+0.8	−0.4	—	+0.5	—	+0.5	+0.3
15		4	—	+0.9	—	+0.4	+0.2	+0.3	—	+0.5	—	−0.0	+0.4
16		5	—	+1.2	—	+0.6	+0.7	+0.7	—	+1.0	—	+0.9	+0.9
17		6	—	−0.1	—	−0.8	−0.8	+0.1	—	−0.4	—	−0.2	−0.4
18		7	—	−0.4	−0.7	−1.1	−0.6	−0.6	—	−0.5	—	−0.5	−0.6
19		8	+0.6	+0.0	−0.3	+0.0	−0.3	+0.4	+0.1	+0.4	—	+0.2	+0.1
20		9	+0.2	+0.1	−0.3	−0.4	−0.2	−0.4	−0.1	−0.3	—	+0.3	−0.1
21		10	−0.0	−0.2	−0.3	−0.4	−0.6	−0.3	−0.5	−0.4	—	−0.2	−0.3
22		11	+0.8	+0.4	+0.4	0.0	+0.6	+0.8	−0.5	+0.5	—	+0.0	+0.3
23		12	−0.2	+0.3	+0.1	+0.0	+0.4	+0.6	+0.2	+0.4	—	+0.2	+0.2
24		13	−0.7	+0.3	0.0	+0.1	−0.1	−0.3	+0.7	−0.1	−0.2	+0.1	0
25		14	−0.2	+0.4	−0.2	+0.1	+0.0	+0.0	+0.3	−0.1	+0.1	+0.1	+0.0
26		15	−0.1	+0.5	+0.1	+0.1	−0.3	+0.3	+1.7	+0.3	+0.5	−0.0	+0.2
27	Syōwa	2	+0.0	+0.3	−0.1	−0.1	−0.1	+0.3	−0.1	+0.1	−0.5	−0.0	−0.0
28		3	+0.1	−0.1	−0.3	+0.1	+0.1	+0.3	−0.7	−0.2	−0.6	±0.0	−0.1
29		4	+0.8	−0.2	+0.0	+0.1	+0.1	+0.7	−0.1	+0.3	−0.1	+0.2	+0.2
30		5	+0.7	−0.1	+0.5	+0.5	+0.2	+1.1	−0.3	+0.9	+0.1	+0.4	+0.4
31		6	+0.7	−0.6	−0.0	+0.1	−0.3	+0.7	−1.0	−0.1	−0.1	+0.2	0
32		7	+0.2	−0.3	+0.1	−0.3	−0.2	+0.9	+0.1	−0.4	−0.1	−0.2	0
33		8	−0.5	−0.2	+0.2	+0.2	+0.3	−0.1	0.0	−0.1	+0.2	−0.2	0
34		9	−0.9	−0.9	−0.7	−0.7	−0.1	−0.8	−0.8	−0.7	−0.5	−1.0	0
35		0	−0.6	−0.1	+0.1	−0.1	+0.1	−0.3	−0.2	−0.2	+0.3	−0.4	−0.7
36		11	−0.9	−0.6	−0.6	−0.6	−0.5	−2.5	−0.4	−0.7	−0.5	−0.3	−0.1
37		12	+0.2	+0.3	+0.3	+0.5	+0.6	−0.9	+1.1	+0.0	+0.4	+0.6	−0.8
38		13	−0.2	−0.2	−0.0	−0.2	+0.0	−1.1	+0.4	−0.1	+0.1	+0.1	+0.3
39		14	+0.1	−0.0	−0.1	+0.3	+0.1	−1.0	± 0	+0.3	+0.2	+0.1	−0.1
40		15	−0.2	−0.4	−0.1	−0.3	−0.0	+0.1	−0.1	−0.0	+0.5	−0.3	0
41		16	−0.6	−0.6	−0.5	−0.1	−0.2	−0.5	−0.1	+0.8	−0.1	+0.3	−0.2
42		17	−0.0	± 0	+0.2	+0.5	+0.4	+0.2	+0.3	−0.4	+0.3	+0.4	+0.2
43		18	−0.4	−0.8	−0.6	−0.6	−0.1	−0.2	−0.4	−1.3	−0.5	−0.2	(−0.6)
44		19	−0.1	−0.5	0.0	+0.5	+0.6	+1.0	−0.5	−0.7	−0.8	−0.1	(−0.1)
45		20	−1.4	−1.1	—	—	0.0	—	−1.5	−2.2	−1.9	−0.4	(−1.2)
46		21	−0.9	−0.2	—	—	−1.0	—	(+1.5	−1.4	−2.0	−0.1	(−0.6)
47		22	−0.8	−1.0	—	—	+0.2	—	−0.4	−1.0	−0.5	−0.3	(−0.6)
48		23	+0.7	+0.3	—	—	+0.4	—	+0.4	−0.6	−2.1	+0.5	(−0.1)
49		24	−0.8	−0.6	—	—	−0.3	—	−0.6	−0.9	—	−0.0	(−0.5)
50		25	(−0.2)	+1.7	—	—	(+1.4)	—	+1.1	(0)	—	+1.1	(−0.8)
Statistical Year			32	38	27	31	38	31	32	38	25	38	38

Table 3. (F) Anomaly of annual mean water temp. (°C)
On the Eastern coast of Korea.

Location		Ranto Is.	Seisin	Busuikan	Zyōsin	Bixyō Tō	Rei Tō	Sugentan	Tyūmonsin	Tippen	Hokō	C. Tyanzen	C. Urusaki	$\frac{f_1}{f_{12}}$
Year	Era	f_1	f_2	f_3	f_4	f_5	f_6	f_7	f_8	f_9	f_{10}	f_{11}	f_{12}	Mean
1919	Taisyō 8	—	—	+0.1	—	—	—	+0.5	+0.4	+0.3	−1.0	—	—	+0.3
20	9	—	—	+1.1	—	—	—	+1.5	+0.9	+1.6	+1.5	—	—	+1.3
21	10	—	+1.0	+1.1	—	—	—	+1.2	+0.8	+1.5	—	—	—	+1.1
22	11	—	+0.5	+0.1	—	—	—	+0.4	+0.9	+1.3	—	—	—	+0.6
23	12	—	+0.2	+0.6	—	—	—	+0.2	+0.2	+0.6	—	—	—	+0.4
24	13	—	−0.3	−0.5	—	−0.4	+0.1	−0.4	−0.0	+0.2	—	—	—	−0.2
25	14	—	+0.2	−0.2	—	+0.5	+0.1	−0.2	−0.8	+0.4	—	—	—	0
26	15	—	−0.2	−0.2	—	−0.4	−0.3	−1.2	−1.9	−1.0	—	—	—	−.9
27	Syōwa 2	—	+0.3	−0.0	—	−0.6	+0.3	−0.3	−0.7	−0.8	—	—	—	−.3
28	3	—	−0.1	±0.0	—	−0.3	−0.3	+0.0	−1.5	+0.7	—	—	—	−.2
29	4	—	−0.4	−0.1	—	−0.6	−0.1	−0.1	+1.0	−0.2	—	—	—	−.1
30	5	—	+0.3	+0.2	—	+1.3	+0.3	+0.9	+1.1	+1.1	—	—	—	+.7
31	6	—	−1.2	+0.7	−0.8	−1.0	−0.7	−0.8	+0.2	+0.1	−0.4	+0.1	—	−0.4
32	7	—	−0.5	−0.8	−0.6	−0.7	−1.9	−1.2	−0.9	−0.0	−0.3	+0.0	—	−0.8
33	8	—	+0.4	+0.3	+0.6	+0.4	−0.5	+0.6	+0.3	+0.6	−0.0	−0.4	—	+0.2
34	9	—	−0.6	−1.0	+0.2	−0.6	−0.5	−0.6	−0.0	± 0	−0.5	−0.5	—	−0.4
35	10	+0.2	+0.3	+0.1	+0.4	+0.3	+0.6	+0.5	+0.7	+0.8	−0.1	+0.2	—	+0.4
36	11	−0.2	−0.1	−0.7	−0.1	−0.5	−0.9	−1.2	−1.5	−1.6	−1.7	−1.9	—	−1.0
37	12	+0.1	+0.6	+0.1	+0.5	+1.2	+0.8	+1.0	+0.4	−0.4	+0.3	+0.2	—	+0.5
38	13	+0.4	+0.3	+0.3	+0.2	+0.2	+0.1	−0.2	+0.4	−0.7	+0.1	−0.1	—	+0.1
39	14	+0.9	+0.7	+0.9	+0.8	+1.0	+0.7	+0.3	+0.1	+0.7	+1.1	+1.7	+0.5	+0.8
40	15	−0.2	−0.2	−0.2	−0.4	−0.1	+0.4	+0.9	−1.3	−0.9	−0.7	−0.1	−0.6	−0.3
41	16	−0.6	−0.6	−0.3	−0.7	−0.1	+0.3	−0.9	−0.7	−0.7	+0.2	−0.3	−0.1	−0.4
42	17	−0.4	−0.7	−0.3	−0.4	−0.1	−0.2	+0.8	+1.2	+0.3	+0.5	−0.1	+0.0	0.0
43	18	+0.2	+0.2	+0.2	+0.4	+0.5	+0.4	+0.2	—	—	—	—	—	+0.3
44	19	+0.2	+0.5	+0.2	+0.0	+0.5	+0.4	+1.6	—	—	—	—	—	+0.5
45	20	−1.1	−0.6	−0.4	−1.5	−0.1	+0.3	−0.1	—	—	—	—	—	−0.5
Statistical Year		11	25	27	15	22	22	27	24	24	14	12	4	

ther with the poor transport of the youngs into the coastal area owing to the weak inflow of Kuroshio Branch in spring, were clearly recognized since after 1942 and were not recovered during several years. (See Fig. 4).

(iii) It is considered that the cause of the northern displacement of the main sardine spawning ground, accordingly of the main fishing ground, to the region centered in Gotō Nada off Nagasaki Pref. may be partly in the decrease of the coastal water temperature along the coast of Japan in recent years, especially in the southern coastal water off Kyūshū. (Fig. 2). Corresponding to the development of the Tsushima Current, the fishing areas in 1949 and 1950 indicate more prosperous extension than that in the former years along the coast of the Japan Sea side.

The rich years of the oriental sardine fishing (abundant period) such as the recent rich period 1926–40 correspond to the prosperous northern extension period of warm current and to the weak cold current, in particular the abundant sardine period in the northern waters (Hokkaidō, North Korea and the NE Sea-region of Japan). On the contrary, during the bad years of sardine fishing such as the period of 1942–48 the decline of the yield in the northern waters correspond to the decay of warm current and to the prosperity of the cold current.

The general feature of the decline of sardine fishing began first from the northern region and then gradually propagated to the south (See Fig. 3). The decline of the sardine yield began in Hokkaidō from 1941, in Miyagi Pref. from 1943 and in Chiba Pref. rapidly from 1945. Conversely the rich fishing period began from the southern waters and propagated gradually to the north. However, in the NE Sea-region of Japan the phase of max. yield lags from north to south. (Fig. 3) Or in other words, entering in the bad years the extension of sardine fishing areas shrink year by year to the south in accompany with the shrinkage of the migration route. The delay of the beginning and the prosperous fishing period, the offshore-going tendency of sardine shoals (not approaching near the coast), the decrease of the fat content in the fish body are the common signs of bad years. It is noted that in the bad fishing years of sardine the water temperature falls commonly, especially a conspicuous descent in the southern coastal waters off Kyūshū. In general the period of cold water temperature (i. e. the period of the weak warm current and the strong cold current along the Japan coast) coincides well with the bad fishing years of sardine.

(iv) Basing on the literatures[10)–15)] in the historical past ages we can find the three maxima and minima in the fluctuation of sardine yield in our country. The first good fishing period (its max. in 1716–19) of the years 1680–1730 and the first bad fishing period (its minimum in 1768–80) of the years 1736–89, the second good fishing period (its max. in about 1830) of the years 1818–54 and the second bad fishing period (its min. in about 1885) of the years 1875–1902, the third good fishing period (its max. in about 1936–37) of the years 1929–39 and the recent bad fishing period (its min. 1946–47) of the years 1941–49 can be found. Thus the interval between the first max. and second max., and that between the second and third max. are 113 aud 106 years respectively. Hence it seems that a long cyclic change of nealy one century interval exists in the fluctuation of sardine yield.

The recent decline of the sardine yield is the world-wide phenomenon not only in the waters adjacent to Japan but in the whole oriental waters

also in the pacific American waters including the California fishing area, further presumably in the European waters. The origin of the phenomenon may be attributed to the cosmic one or geophysical (oceanographical or meteorological) one. It was already reported that the fluctuation of the European herring fishery[15] and that of the tunny fishery in the Mediterranean seas[16] show the long period of 110 years, and also of the cod fishery in the Atlantic Ocean the period of about one century[17].

According to the results of our investigation, the fluctuation of the yield of sardine appears hand in hand with those of tunnies (albacore, yellowfin tuna, bluefin tuna and skipjack) and inversely to those of herring, squids, pacific saury and cod (See in Fig. 5). Now, remarking on the tendency of

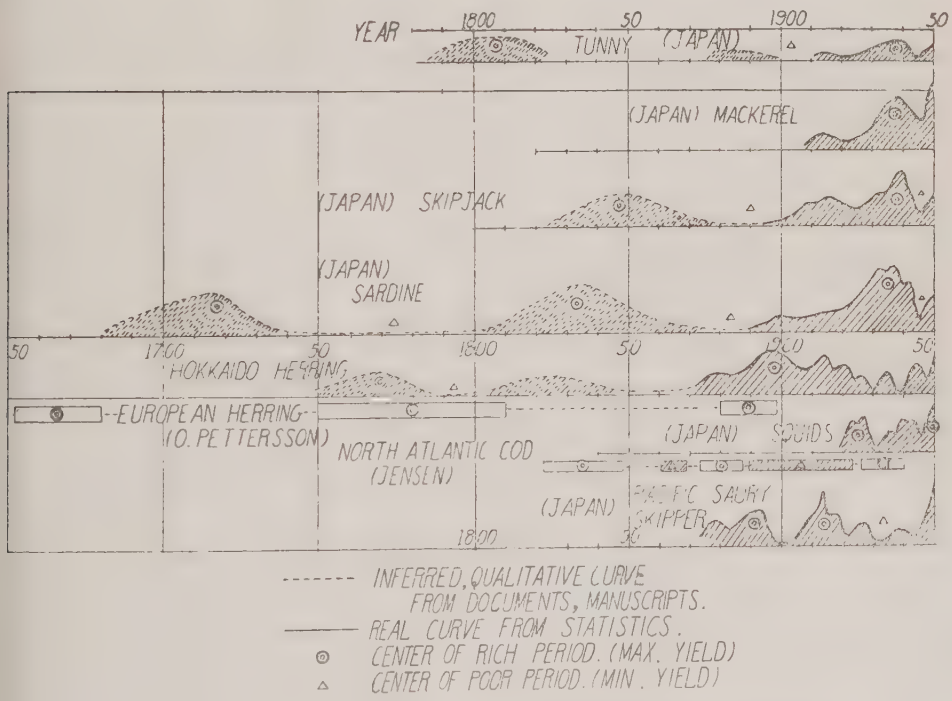


Fig. 5. Long period variations of the catches of the important fishes.

rising water temperature from the lower level gradually from south to north and glancing on the past history of fluctuation, we can see the present state of sardine fisheries, passing through the min. gradually and entering into a new small undulation superposed upon the large undulation of secular period.

Table 4. Water temperature in the regular hydrographical section observed by the Kagoshima Pref. Fish. Expt. St. (θmax., θmix.···max. and min. temp in the section.)

Year	Date	Ōsumi Strait		Tokara Strait		Yokoate Is. W.	
		θmax.	θmin.	θmax.	θmin.	θmax.	θmin.
		(0m)	(150m				
1922	Feb. 18	19.5° C	17.6° C	—	—	—	—
1928	〃 27	20.5	16.2	—	—	—	—
1931	〃 26	20.8	16.9	21.7° C	18.5° C	—	—
1932	〃 11–12	21.0	17.3	21.7	20.0	20.7	19.5
1933	〃 15–16	19.0	14.7	21.5	17.0	—	—
1934	〃 18–19	18.4	15.1	21.5	19.1	—	—
1935	〃 10–11	18.0	14.5	20.6	16.5	21.5	*15.8*
1936	〃 13–14	18.5	14.3	21.3	17.8	21.5	16.3
1937	〃 24–27	22.0	17.1	22.3	19.3	23.0	20.5
1938	〃 23–24	20.0	*13.8*	22.3	18.0	22.4	20.0
1940	〃 21–25	*16.5*	*12.7*	*20.4*	*15.1*	22.1	19.1
1918	Mar. 28	16.4	13.5	18.6	15.4	—	—
1921	〃 23	22.3	18.0	—	—	—	—
1929	〃 6	17.9	15.5	—	—	—	—
1930	〃 17	18.2	15.3	—	—	—	—
1933	〃 26–27	18.6	15.2	22.5	16.5	—	—
1934	〃 10–11	19.2	*13.0*	21.2	16.8	—	—
1935	〃 22–26	20.0	15.5	22.2	17.0	24.3	19.0
1936	〃 28–30	19.3	16.1	21.1	14.8	21.6	18.8
1937	〃 27–30	20.6	14.8	22.9	19.3	24.1	17.3
1939	〃 29–30	*17.9*	*12.4*	21.8	*12.5*	25.9	20.5
1917	May 28	23.8	15.1	24.4	15.7	—	—
1918	〃 2	22.2	19.6	21.9	19.4	—	—
1919	〃 19	20.6	*14.0*	—	—	—	—
1922	〃 14	22.4	16.0	—	—	—	—
1928	〃 22	22.5	15.7	—	—	—	—
1931	〃 17–18	22.1	16.5	25.0	19.0	—	—
1932	〃 13–14	21.5	15.2	25.4	17.2	26.0	18.8
1935	〃 15–17	21.0	16.3	25.5	17.2	26.5	20.0
1936	〃 11–15	22.5	*15.0*	25.1	18.2	26.2	17.5
1937	〃 14–16	24.6	17.4	26.0	17.7	26.2	19.0
1939	〃 22–24	23.0	*14.5*	24.5	*16.8*	25.9	20.5
1940	〃 14–19	23.2	*15.0*	23.3	18.3	24.5	19.0

3. The Relation Between the Fluctuation of Bluefin Tuna* and the Oceanographical Conditions in the Southern Seas of Japan

Hitherto it was considered that the tuna fishery in the pacific ocean is not yet disturbed by overfishing and obeys to the natural fluctuation of its yield due to the oceanographical conditions.

Formerly S. Iehisa (1939) has described the tunny fishing ground south off Kyuūshū during Jan.-March in 1939 correlated intimately with the boundary of water masses [18], and T. Kawana (1934) [19] and T. Kida (1936) [20] discussed the tunny fishery in the southern sea off Hokkaidō in ralation with the sea condition. The present author investigated the materials in the Semi-annual Report of Oceanographical Investigation (1935–41) published by the Imperial Fisheries Experimental Station and obtained the following results. (See Fig. 6).

(i) The most favourable fishing area of tunny lies at the contact zone (having the water temperature 18–20° C) of Kuroshio and the coastal cold water at the south of Kyūshū which appears in winter (Jan., Feb. and March) and along the marginal area of Kuroshio flowing toward NNE direction with the velocity of 1–2.5 knots.

(ii) In the boundary zone of water masses (line of convergence) the two great fishing areas A and B which show the most concentrated shoaling of tunny and both coincide well in the contact zone of the region of max. convergence. In particular the A region corresponds to the best fishing ground which has the max. concentration of tunnies.

(iii) Also the above cited boundary zone of water masses, especially A and B fishing grounds, correspond to the good concentrated feeding fishes of tunny such as pacific saury (appeared from late Dec. to middle Feb.), sardine (spawning migration in Feb.), mackerel and flying fish (in early spring).

The shoals of tunny migrate into those sea regions by the attraction of those feeding fishes and feed them actively in the season.

(iv) The hydrographical fluctuation in the fishing areas was investigated on the basis of the data observed by the Kagoshima Pref. Fish. Expt. St. as follows.

(a) The intensity of warm current flowing through the Osumi Strait easterly in winter (Feb.) of 1933–36 shows its considerable decay in comparison with those of 1928, 1931 and 1932. The values of θ max. (max. temperature in the hydrographic section) and θ min. (min. temperature in it) falls down, particularly low during 1934–36.

* Kuromaguro, *Thunnus Orientalis* (Schlegel).

(b) In the Tokara Strait, before 1934 the water temperature is higher than normal, but in March, 1934 θ min. exhibits the remarkable lowest water temperature and the bottom cold water-mass near the coast. Also the bottom water was cold in Feb. 1935. In the years of 1936 and 1937, the boundary of the water-masses was sharply defined. Moreover in the winters of 1937 and 1938 the north-flowing intensity of Kuroshio denoted by the warm water zone (among the isotherms of 16°, 18° and 20° C the 18° C isothermal line is the most useful indicator) has shown its max. prosperity and flow to the western seas of Kyūshū strongly (with the remarkable high temperature of θ max.)

(c) The water temperature in the Kuroshio area to the west of Amami Ō-shima (west of Yokoate Is.) was comparatively higher in the years during 1937-40 and the temperature gradient between the warm Kuroshio water and the cold coastal water was remarkable in the years of 1938 and 1940.

(v) Abnormal rich fishing of tunny with the hydrographical variation.

(a) In the year of 1938 the Kuroshio water in the East China Sea was warmer than normal generally, and the whole Tsushima Current area

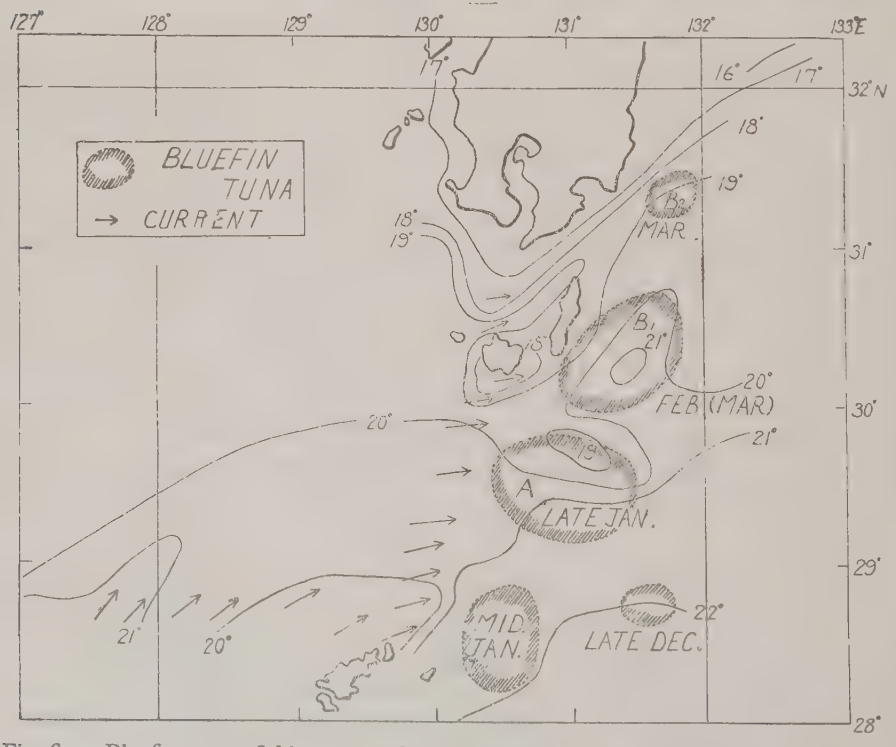


Fig. 6 a. Bluefin tuna fishing grounds in winter of 1935 and the distribution of corresponding water temp. θ at the depth of 100 m. and the surface currents.

in the Japan Sea was also warmer than normal. In the winter of that year the preliminary favourable catch of tunny in the western seas of Kyūshū was reported.

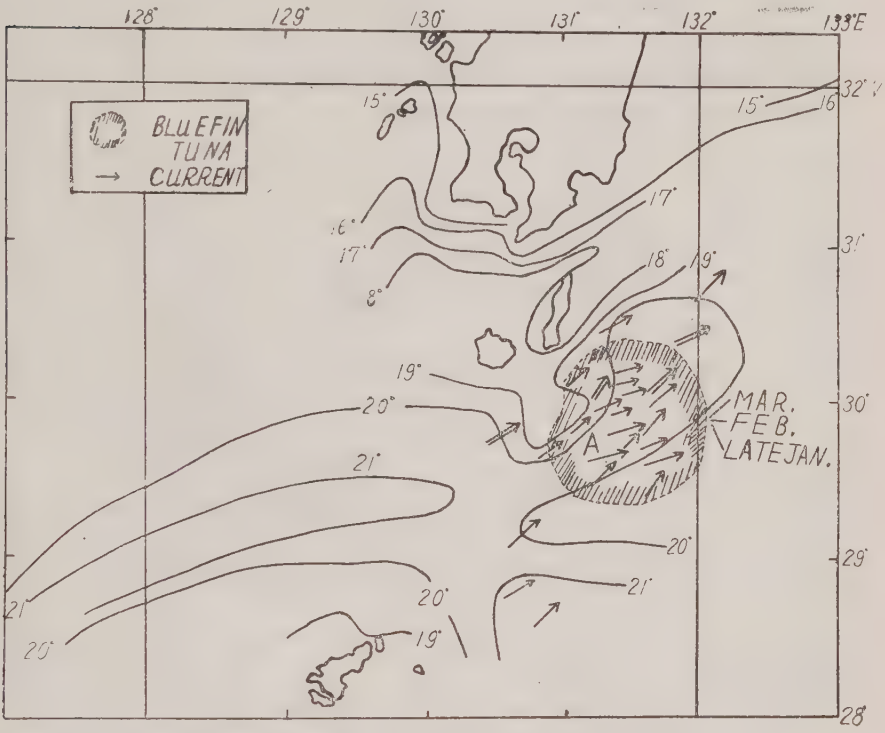


Fig. 6 b. Bluefin fishing grounds in winter of 1936 and the distribution of corresponding water temp. at the depth of 100 m. and the surface currents.

(b) In the winters of 1939 and 1940 the coastal water-mass along the southern coast of Kyūshū, extended to to the south and covered the nieghbouring region of Yakushima.

(c) Soon after the storm of Feb. 5–6, 1939 the water temperature has fallen suddenly and with the decay of catch in the region of Tanegashima, the schools of large tuuny rushed to north along the west coast of Kyūshū in Feb. and March which brought an unexpected abundant catches to the coastal fishing grounds and in April entering in the Japan Sea still the abundant catches continued. In March of that year the upwelling of an anomalous cold water-mass was found in the bottom layer near the coast of Kagoshima Pref. In the next winter of Feb. 1935 again the adjacent waters of Kagoshima Pref. has shown remarkably low temperature (in Ōsumi Strait ····· θ max. 16.5° C, θ min. 12.7° C), in Tokara Strait ····· θ max. 20.4° C, θ min.

15.1°C). And the good tunny catch along the western seas of Kyūshū resembled to the previous year with less abundance (which migrated to the north-western region of Kyūshū from late Jan.)

(vi) Basing on the above investigations (refer Fig. 6), we can conclude that during the years 1936-40 the stream-axis deviated westerly compared to the normal year and the branching center of Kuroshio has shown its translation to the south-western region.

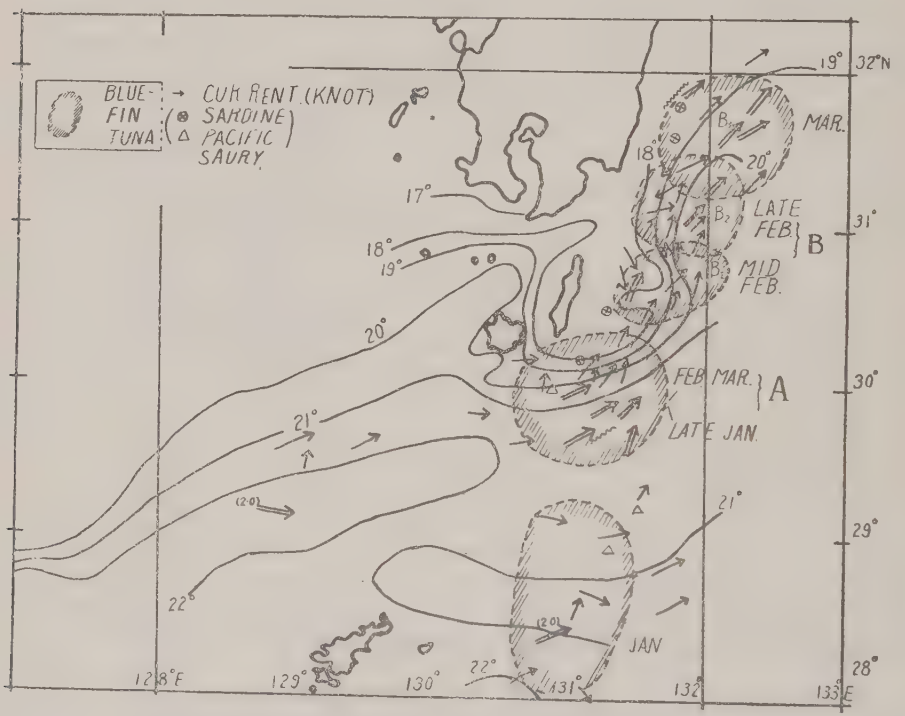


Fig. 6 c. Bluefin tuna fishing grounds in winter of 1937 and the distribution of corresponding water temp. at the depth of 100 m. and surface currents (knots) with the food-fishes.

(vii) According to the sectional observation in the Osumi Strait in spring (May), during in the years 1936-40 the water temperature is relatively high, showing its maximum prosperity in 1937 of θ max. 24.6° C (in Tokara Strait 26.0° C).

(vii) In the sea-region south of Kagoshima Pref. in winter as similar to the anomalous cold water-mass in the sea-region south of Sio no Misaki (Kumano Nada) in spring, during the same years 1936-40 the coastal cold water-mass appeared from the deeper layer.

The origin of this coastal cold water-mass is concluded almost as the upwelling of the coastal deeper water corresponding to the southwestern re-

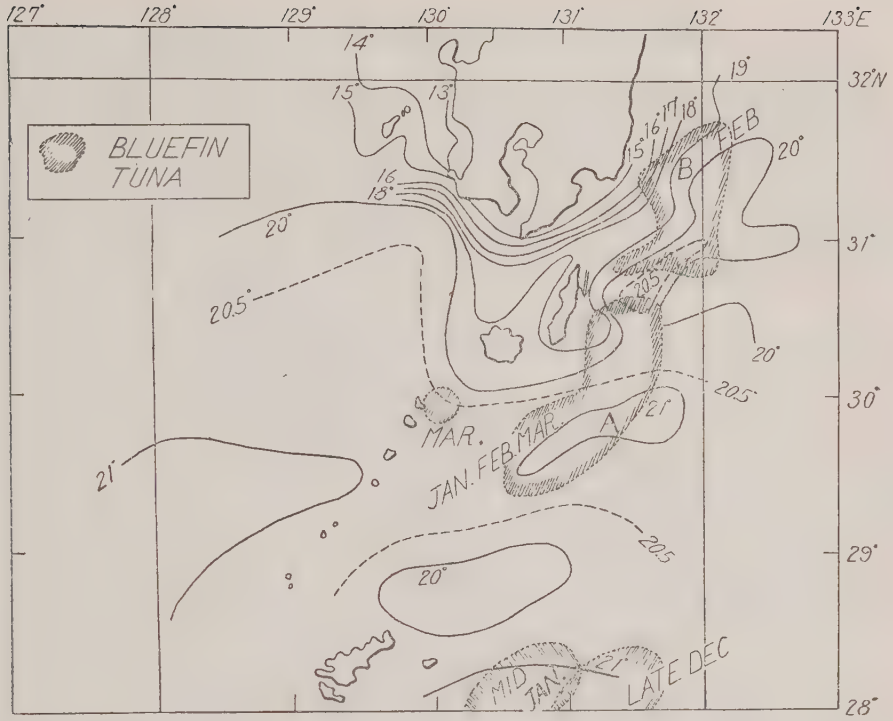


Fig 6 d. Bluefin tuna fishing grounds in winter of 1938 and the distribution of corresponding water temp. at the depth of 100 m.

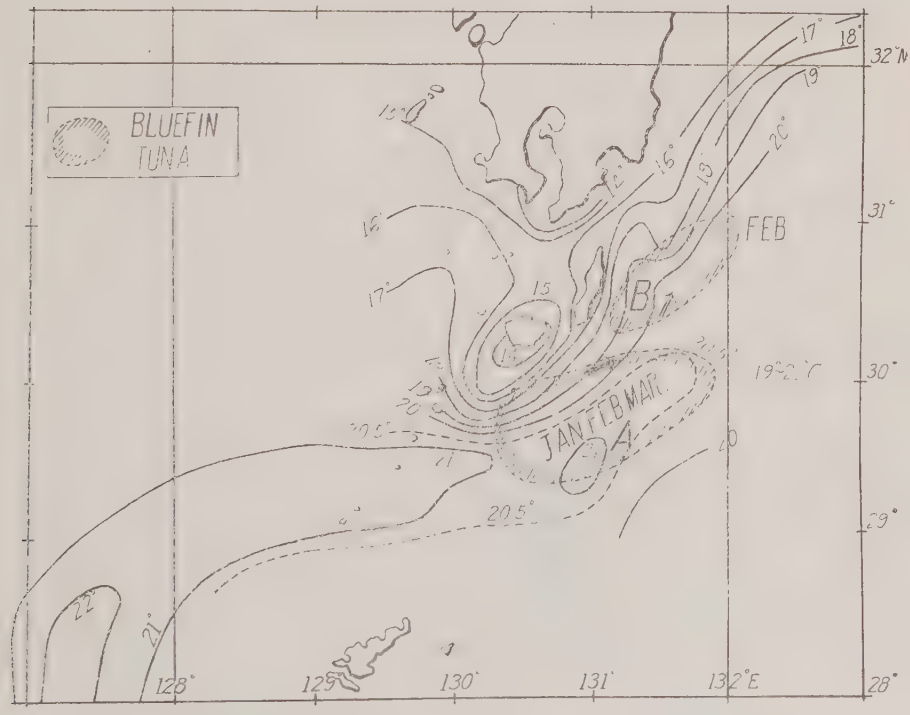
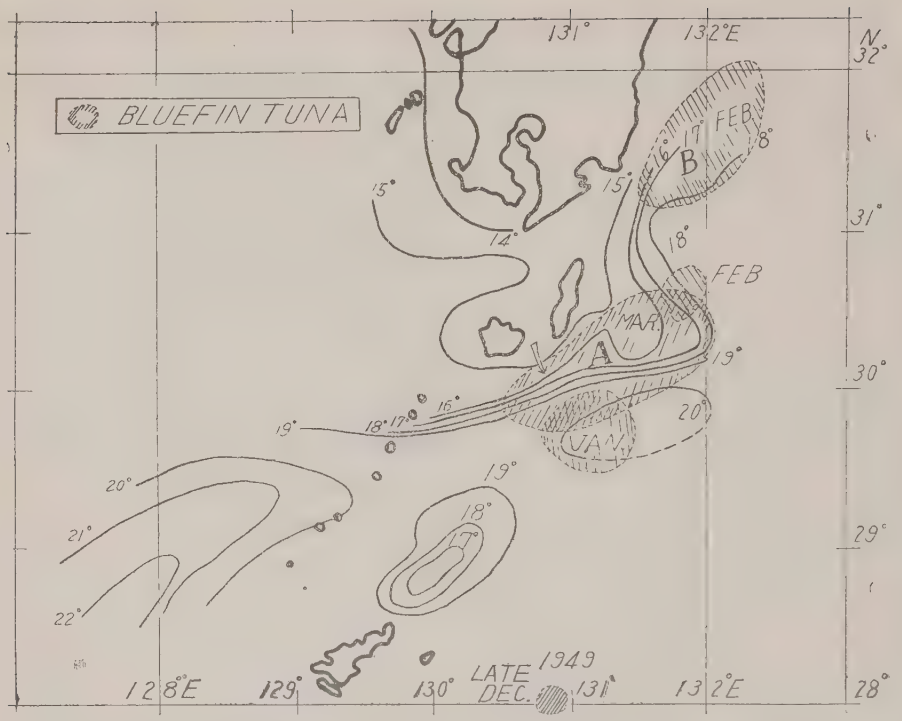


Fig. 6 e. Bluefin tuna fishing grounds in winter of 1939 and the distribution of water temp. at the depth of 100 m.



Fsg. 6 f. Bluefin tuna fishing grounds in winter of 1940 and the distribution of water temp. at the depth of 100 m.

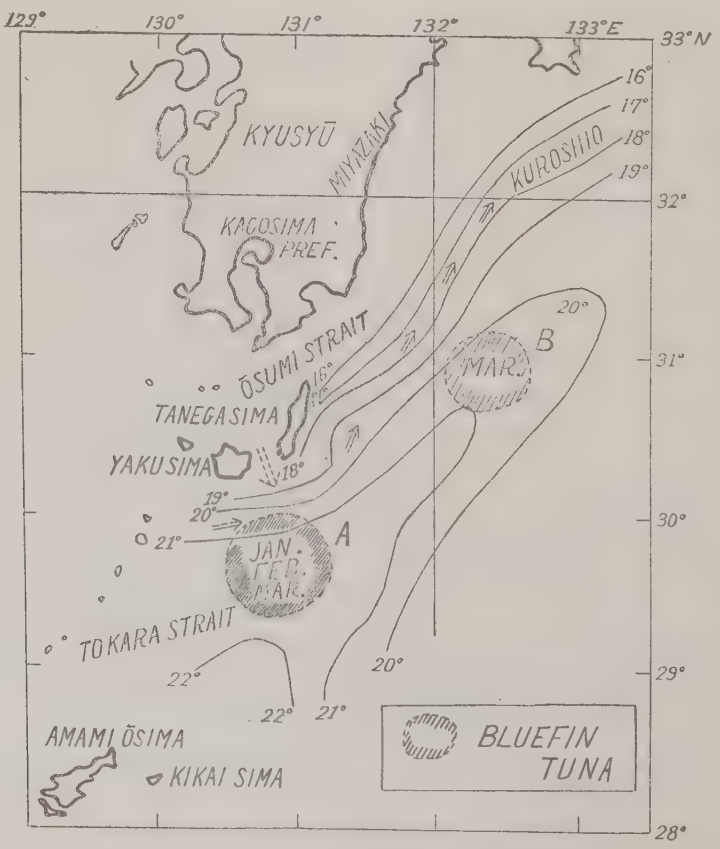


Fig. 6 g. Bluefin tuna fishing grounds in water of 1941 and the diftribution of water temp. at the depth of 100 m.

treat and decay of Kuroshio. It is inferred that the above is merely one of the local phenomena in the chain-like variations connected with the recently prevalent cold water circulation in the North Pacific Ocean.

(ix) The anomalous entrance of the tunny shoals into the Japan Sea from the southern and the western seas off Kyūshū in the years of 1939 and 1940 occurred after about 60 (50-70) years of the rich period (the last tunny yield in Nagasaki Pref. was 1123 tons in 1891).

The former and the latter abundant catches of tunny corresponds nearly to the max, period of the sun-spot number and perhaps due to the fluctuation of Kuroshio.

(x) After about 1941 tunny disappeared from the seas south off Kyūshū and also about at the same time from the seas south off Formosa (Takao)[21]. Moreover, the catch of tunny in the south seas of Japan became conspicuous from about 1923 and lasted to the year 1941 which shows an interesing coincidence with the rise and decay of the oriental (northern) sardine fishery. We can not decide whether the tunny stock decayed or emigrated to somewhere.

In the years 1950 and 1951 the tunny appeared in increasing number and especially the relative abundance of the youngs was observed.

Probably it means that the rise of the tunny fishery in accompany with the rise of coastal water temperature passing through the cooler period.

4. The Relation Between the Yellow-fin Tuna Fishing Ground in the Equatorial Pacific and the Hydrographical Fluctuation

Formerly H. Marukawa reported that the Equatorial Counter Current region exhibits excellently high productivity and rich in plankton organisms due to the upwelling of cold and nutrients rich deeper water[22].

Also the fisheries agency of the former Japanese mandate (e. g. H. Kawamura etc.) reported the above sea region as the favourable fishing ground of tuna[23].

(i) Investigating in the reports obtained by the research fishing vessels of the local prefectural fisheries Expt. St. in the years 1939-41 (the Semi-annual Report of the Oceanographical Investigation) the present author indicated in Fig. 7 that in the long-line fishing ground (east of 130° E. and south of 22° N.) the catches of yellow-fin tuna show its max. against the water temperature at the sea surface 28°–29° C, while against the water temperature at the depth of 100 m. two maxima 24°–25° C and 28°–29° C respectively. (Fig. 7).

The maxima of the number of the fishing boats in a year and its yield of ths yellow-fin tuna at Misaki Harbour occur in winter, Dec. and Feb. (winter monsoon period and the most prosperous period of NE trade wind and the North Equatorial Current) and the minima occur in summer-autumn of Aug. Sept. and Oct. (typhoon period). The catches of black marlin and the big-eyed tuna indicate also the nearly similar annual variation.

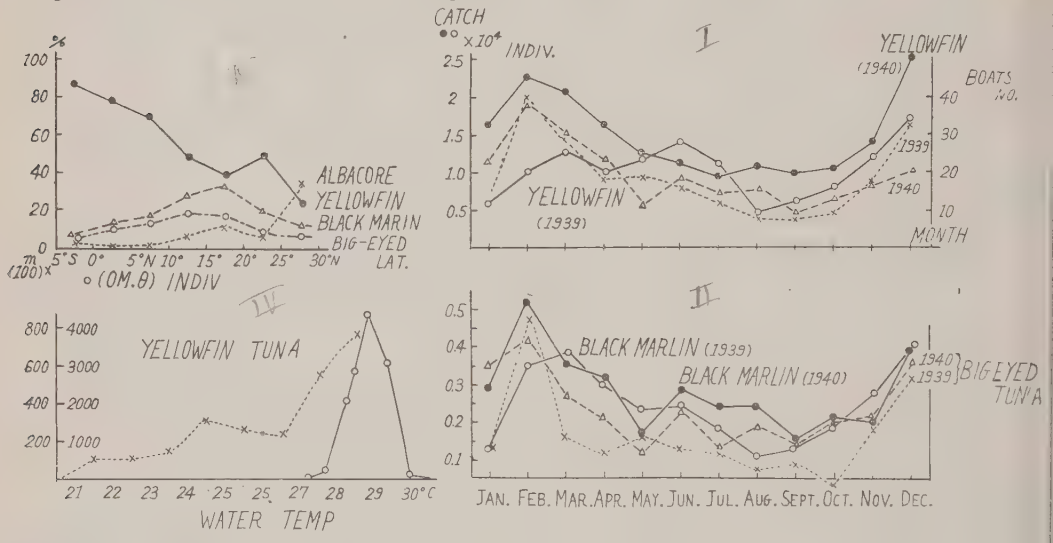


Fig. 7. (i) Annual variation (in 1939, 1940) of the catch of Yellowfin and the number of fishing boat; (ii) Annual variation (in 1939, 1940) of the catch of Black Marlin and Big-eyed Tuna; (iii) Meridional distributions of Albacore, Yellowfin, Black marlin and Big-eyed Tuna in the NW-Pacific; (iv) The optimum temp. of Yellowfin Tuna.

(ii) The distribution of the catch of the yellowfin tuna is most abundant at 0–10 N., and then toward north unto about 30°N., decreases gradually. Since the water temperature changes abruptly near about the line of the subtropical convergence of 20–25° N, a small max. of the catch is shown probably due to the accumulation of fish shoals by the existence of convergence.

Proceeding in detail at that period the main fishing ground of the yellow-fin tuna lies in the region of the Equatarial Counter Current and around it, especially most abundant in the zone 145–150° E. and second abundant areas in 140–145 E. and 150–155° E.

Amid them the fishing ground of the black marlin** has its max. catch in 15–20° N. and the fishing ground of big-eyed tuna † has its max. catch in 10–20° N. Accordingly both lies in the region of the North Equatorial Current.

On the contrary albacore (Binnaga Maguro) ※ is abundant in the sea-

* Kiwada Maguro, *Neothunus macropterus* (TEMMINCK & SCHLEGEL)
** Kurokawa, *Makaira Mazara* (JORDAN & SNEYDER)
† Mebati, *Parathunnus Sibi* (TEMMINCK & SCHLEGEL)
※ Binnaga, *Germo germo* (LACÈPÈDE)
∴ It coincides well with the charts for yellowfin[21].

region to the north of 25° N, and rapidly it decreases to the south of 25° N. Therefore we may consider that albacore is distributed and migrated in the Kuroshio and its extension-area together with in the Kuroshio Counter Current area, which covers the broad sea-region between the Subarctic Convergence (Polar Front) and the Subtropical Convergence.

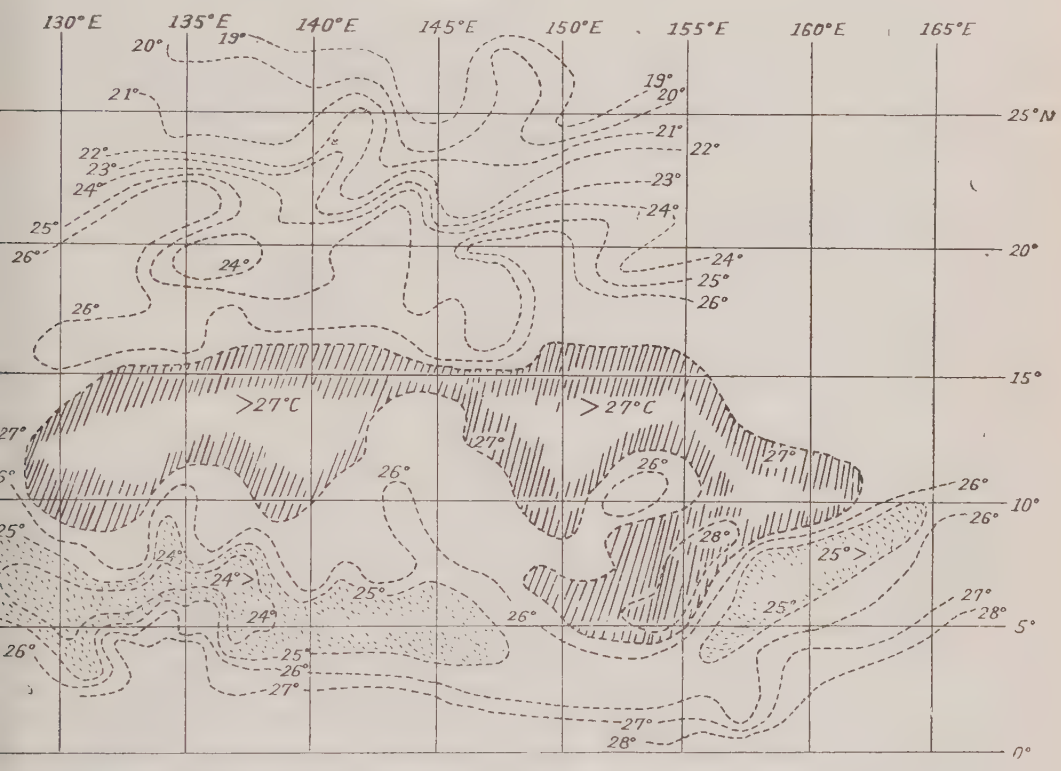


Fig. 8. Distribution of water temp. (°C) at 100 m. depth ("Mansyū" survey. 1925–1928) in the NW–Pacific.

(iii) As for the Equatorial Counter Current, comparing the distribution of currents in the paper by G. Schott[24] with that the distribution of the water temperature at 100 m. depth in the H.M.S. "Mansyū" Reports (1925–28 survey)[25], we can easily show the belt of cold water (min. temperature less than 25° C.) in the zone of 5–10° N. (against the high temperature above 27° C in the zone 9°–16° N. of the North Equatorial Current area. However, the results of observation obtained by the fisheries research boats in the equatorial pacific ocean during 1939–41 are very different from the results above-mentioned.

Compared to the period before more than ten years the Equatorial Counter Current area is far broader and in its portion of lowest water tem-

perature remarkably lower (1°–2° C) than the former, moreover in accompany with the northern displacment of the portion of the highest water temperature to 10–15° N. and its shrinkage in the North Equatorial Current. (Fig. 8 and 9.).

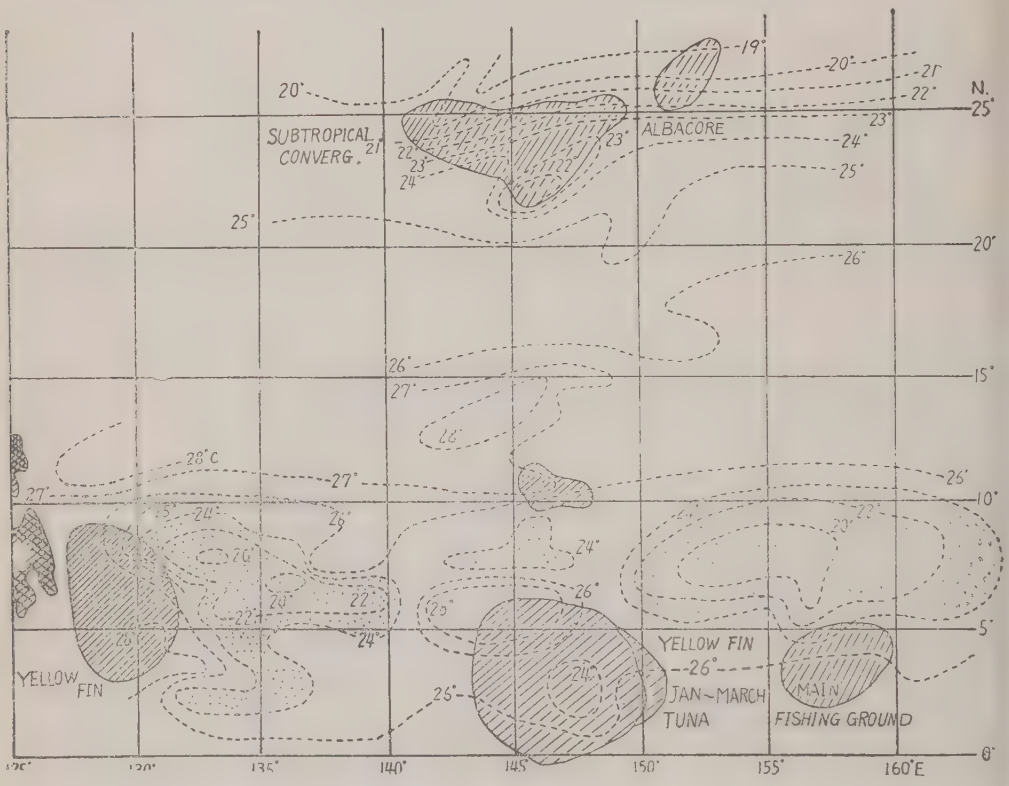


Fig. 9. Distribution of water temp. at 100 m. depth and tuna fishing grounds (Winter in 1939–41) of Japanese fishing boats.

Summarizing the above discussion we can conclude that in the period of the years 1939–41 owing to the prevalent cold water circulation in the North Western Pacific Ocean (from the seas adjacent to Japan to the equatorial pacific) the water temperature in the Equatorial Counter Current is lower than that of the former period. At present, after the World War II, the water temperature at 100 m. depth observed by the fisheries research boat "Sagami Maru" of the Kanagawa Prefectural Fish. Expt. St. during Jan. May in 1951 [20] in the sea region (1°–6° N., 154°–162° E.) lies between 27°–28.7° C, which are above 2° C higher than the temperature in 1939–41, and slightly higher than that in 1925–28 ("Mansyū" Rep.) i. e. it shows the recovery from the abnormal low temperature in 1939–1941.

(iv) Estimating the values of convergence and divergence numerically in winter and summer on the current charts by G. Schott for every rectangle (Lat. 1° Long. 1°) and plotting them in the charts, we get the distributions as shown in Fig. 10 and 11.

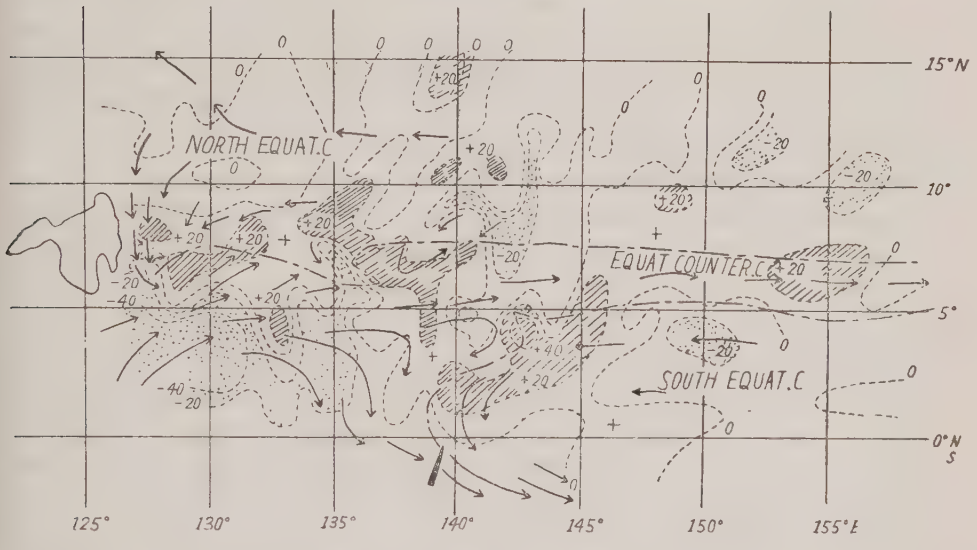


Fig.10. Currents and convergence in winter in the equatorial divergence (−). NW-Pacific. Convergence (+), (Curr. after G. Schott).

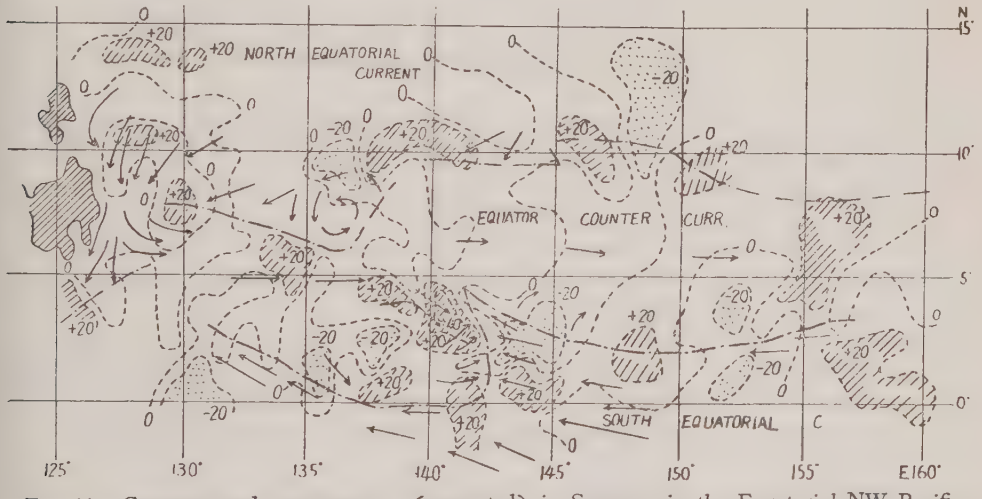


Fig. 11. Currents and convergence (computed) in Summer. in the Equatorial NW-Pacific. (Curr. after G. Schott).

$$\begin{array}{c} u_1 \quad v_2 \\ v_1 \\ \\ v_4 \\ u_4 \quad u_3 \end{array} \begin{array}{|c|} \hline \\ \mathrm{K} \\ \\ \hline \end{array} \begin{array}{c} u_2 \\ \\ v_3 \end{array} \quad ; \quad \mathrm{K} = -\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}\right) = \frac{1}{2}\left\{\begin{array}{l}(u_1+u_4-u_2-u_3)\\ +(v_4+v_3-v_1-v_2)\end{array}\right\} \quad ; \quad \begin{array}{l}+,\ \text{Convergence};\\ -,\ \text{Divergence}\end{array}$$

The anti-clockwise swirls including the areas of maximum convergence above computed which exist east off Mindanao Is. and in the region (0°~5° N, 140°~150° E) correspond clearly to the favourable fishing grounds of yellow-fin[21].

(v) Concluding th above, we can recognize the fovourable longline fishing grounds (yellow-fin tuna) in the Equatorial Pacific lies around the water boundary zones between the Equatorial Counter Current and the Equatorial Currents, and especially favourable in the swirls near the southern boundary in winter (between the Equatorial Counter Current and the South Equatorial Current).

Since the Equatorial Counter Current zone is the upwelling region of the deeper water, the sea water is rich in nutrients in spite of the tropical sea and abundant in marine life[27] which is accumulated to the water boundary. In consequence, it forms the favourable tuna fishing ground.

(vi) Since the fluctuation of the Equatorial Counter Current (or the fluctuation of the water temperature at 100 m. depth) correlates with the secular variation of the NE trade wind, the fluctuation of the North Pacific Anticyclone, the fluctuation of the Equatorial Current, the degree of the prevalence of the cold water in the high latitudes etc. the researches on those lines should be remained in future.

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THE BOTTOM CHARACTER OF THE BANKS AND SUBMARINE VALLEYS ON AND AROUND THE CONTINENTAL SHELF OF THE JAPANESE ISLANDS.

By

Hiroshi Niino

(With Plate I–VIII)

I. THE CONTINENTAL SHELF AROUND THE JAPANESE ISLANDS.

a) The submarine configuration.

If one traces the 200 m. bathymeyric line along the continental shelf of the Asiatic Continent, it can be observed that the main islands of the Japanese Islands are connected with the Asiatic Continent through the starites[3,11,30] which are shallower than 200 m. in depth.

There are a remarkable difference between the submarine configuration of the continental shelf bordering the Asiatic Continent and the bordering the Japanese Islands, the former broad and monotonous, the latter narrow and complex. The complexity is especially conspicuous in the tectonic regions, for example, Toyama Bay and Suruga Bay on the *fossa-magna*.

The submarine bottom configuration is also very complicated in some straits or channels where the oceanic current and tidal current are very strong. The existence of many banks is common on the continental shelf. They are also characteristic of the submarine slopes[1] off the Japanese Islands. The banks are located in and near the zone of small islands which are related to a volcanic belt or a tectonic zone.

The many submarine valleys characterise the continental shelf of the Japanese Islands. If one traces the bathymetric line, there is found on the gentle slopes of the continental shelf around the Japanese Islands, a notable change of grade which is very similar to a terrace scarp found on land. Three such changes in grade have been noted. They are at depth of 20 m., 160–180 m, and 300 m. in general but vary somewhat from region to region.

b) The bottom character.

According to the map of the distribution of bottom deposit the Japanese Islands[45] published by the Hydrographical Office of Japan, rock, gravel, sand, mud and clay are distributed irregulary on the flat surface of the continental shelf. Many bottom samples have been collected at stations on the continental shelf and on the banks during the years 1933 to 1952. The total number of stations is more than 4,000 and observation were made on samples from each. The areas of sampling are listed in the following tables.

Table I.

Date of publification	Name of Area	Number of Station	List of Reference
1929-1931	Around Japan.	650	5
1934	Chyoshi, Pacific coast.	26	17
1934	Genzan, Korea	3	16
1935	Zenisu	36	22
1935	Tobishima	1	18
1936	Kitayamatotai	38	28
1936	Musashitai	28	27
1938	Toyama Bay	76	31
1938	Kinsunose	4	32
1938	Ogasawara	4	33
1938	Okinoyama	4	34
1939	Yomeguri	25	37
1940	Kyurokushima	26	38
1940	Kamchatka	65	39
1943	Nakanose	7	40
1944	Oki Bank	277	42
1950	Yokosuka Bay	24	46
1950	Wakasa Bay	1005	47
1950	Kushiro	17 (1000, not published)	48
1950	Sutsu	4	48
1950	Esashi	4	48
1950	Ashizuri, Shikoku	17 (25, not published)	48
1950	Awashima	8	48
?	Onahama	20	
?	Sakito	70	
?	Takashima	50	
?	Matsushima	24	
?	Shimonoseki	5	
?	Taura	50	
?	Erimotai	5	
?	Yellow Sea	500	

The method of collection was not the same at each station. Some samples were obtained by snapper and others by dredge or tube collecter.

The method of collection, position, depth and the occeanic condition at the time of collection were carefully recorded.

Those samples were obtained by author, by the members of the Fisheries Experimental Station, and members of the Hyrographical Office of Japan. All the samples from the above stations were exermined by the author. The results were published in the references listed above.

1) Rock:-

Rocks were dredged from many stations on the flat surface of the continental shelf and also from its steep slope. The character of the rock changes from locality to locality. The author here in describes the sedimentary rocks in detail, because they are very valuable for the solution of the geological problems of the Japanese Islands as related to the bottom configuration and bottom deposits, ustatic changes of sea level, and the tectonic movement of the land.

The geological ages of the bed rock obtained from the see floor were determined by the kinds of fossil, by hardness and texture, and by comparison with the geological surveys of the neighbouring land areas.

There are some difficulties in the determination because the degree of the consolidation of rocks of the same age is not the some on land as on the bottom of the sea. From some stations, the author dredged unconsolidated Tertiary sediments which look like Recent deposits and containing Tertiary fossils having very fresh appearance.[18,24,25] From the other stations, very hard calcareous deposits were obtained in which petrified tests of organisms now living on the bottom were well preserved.

Observations on the rocks dredged from the sea bottom indicate that the range of distribution with depth of Tertiary strata is from the shore to below 400 m.[18,25] and Pleistocene deposits to 100–300 m. Most of the Pleistocene deposits are related to the submarine terrece scarp of 160–180 m. Post-Pleistocene deposits are distributed on bottoms shallower than 20 m. in depth.[29]

2) The fossils from the bottom of the sea.

The occurrences of fossils from the sea bottom can be classified as follows: a) in consolidated bed rock, b) in the soft bottom sediments, c) in gravels[7] d) in bottom deposits as a separate fossils in gravel or sand,[13] e) characteristics of the distribution of the organic remains[26,37] of which the recent condition of the obtained station shows a notable difference in bathymetric range or oceanic condition.

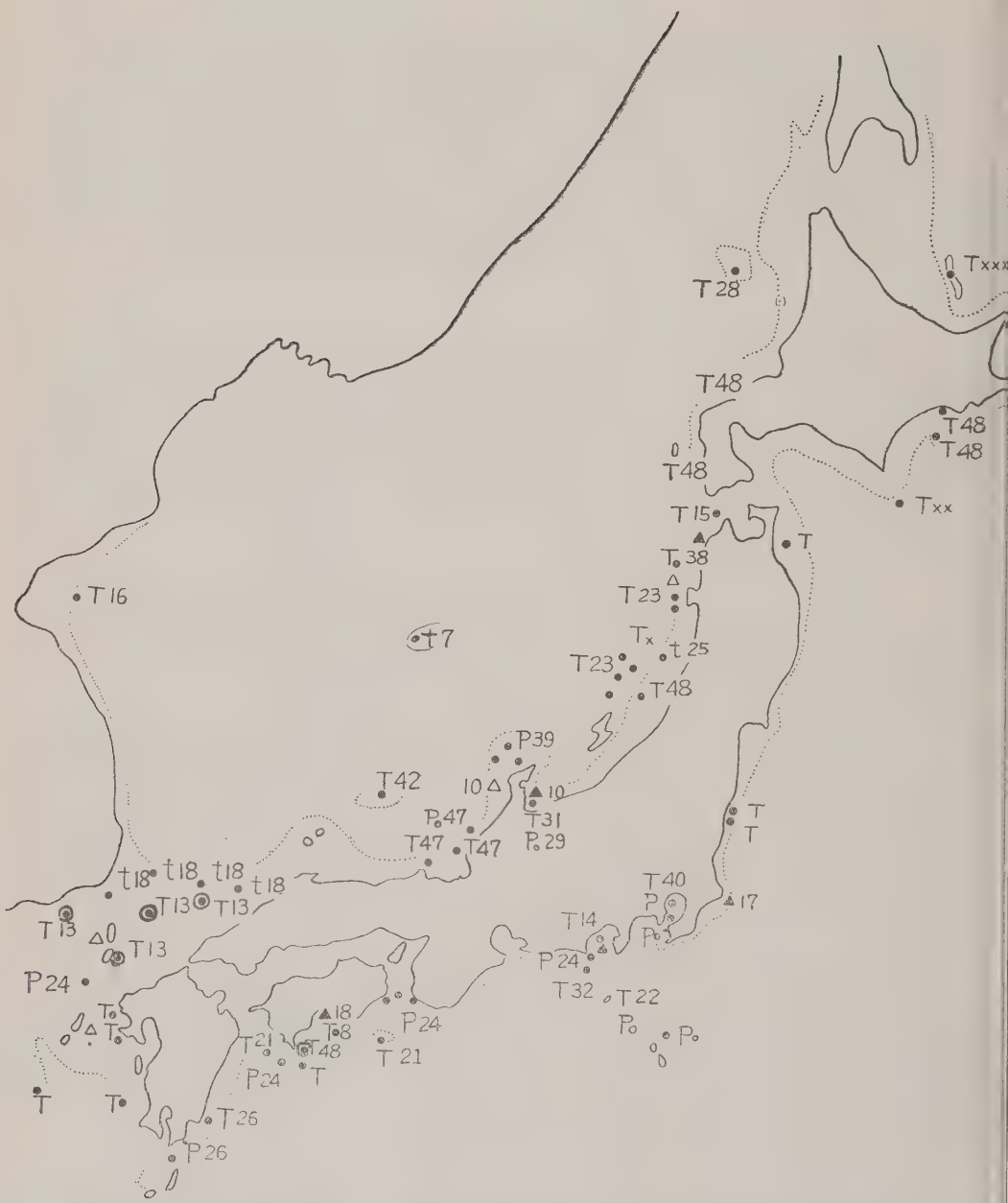

Fig. 1. Map showing the distribution and geological ages of fossil dredged from the sea bottom around the Japanese Islands.

- T. Tertiary fossil obtained from bed rock.
- t. Testiary fossil obtained from soft deposit.
- ⊙ T. Tertiary fossil obtained from the sea bottom where the fossils are separted as like in gravel.
- P_0. Plestocene fossil obtained from soft bed rock or soft deposit.
- + . Palaeozoic fossil? in the gravel.
- × T. See paper 2, this volum.
- △, ▲ Sand pipe

Arabie numerals are numbers of reference paper. See Tables II.

The following is a list of types and geological ages of fossils from the sea bottom around Japan and their occurrence at depth.

Table II.

Geological age	Number of Station	Depth (metres)	Kind of Fossil
Tertiary	160	10–448	Molluscs, Piant
Tertiary?	14	74–604	Sand-pipe
Tertiary	6	117–214	*Thyasira bisecta* Conrad *Thyasira bisecta* Conrad var *nipponica* Yabe et Nomura
Pleistocene	3	275–276	Molluscs
Pleistocene	3	98–108	Molluscs
Pleistocene	11	117–214	*Pecten tokyoensis* Tokunaga
Post-Pleistocene	2	10–20	Peat
Post-Pleistocene	1	2–10	Coral

3) Gravel:—

a) The shape and rock character of the graval.

All the gravels obtained from the continental shelf around the Japanese Islands were well waterworn; there were found no examples of gravels containing striated pebbles of glacial origin or faceted pebbles found in desert regions.

At the stations where soft Tertiary sedimentary rocks were exposed on the sea floor, there was found subangular gravel of the soft Tertiary rock. These gravels may have originated from the rock fragment separated from the bed rock by the action of the boring organisms and then rounded by the mechanical abrasion of water motion.

Gravel were found both with and without attached organisms. From appearance of the attachiment of the organisms, it is possible to determine the position of the gravel fragment on the sea bottom. The rock charcter of the gravels was variable in each station.

b) The distribution of gravels according to their size, matrix, and depth.

There are two types of gravel in relation to the size grade of the gravel and to the matrix. 1) There is visible disparity of size of gravel and matrix. At the stations situated on the outer margin of the continental shelf and the deep bottom around the banks, the gravel fragment are enclosed in a matrix of clay or mud. At some stations the pebbles seem to be half exposed on the sea bottom, because, one side is covered by organisms.[8,47] 2) There is no disparity in the size of gravel and matrix. At some stations on the shallow bottom of contintal shelf and on the banks, the matrix of the gravels consist from coarse materials.

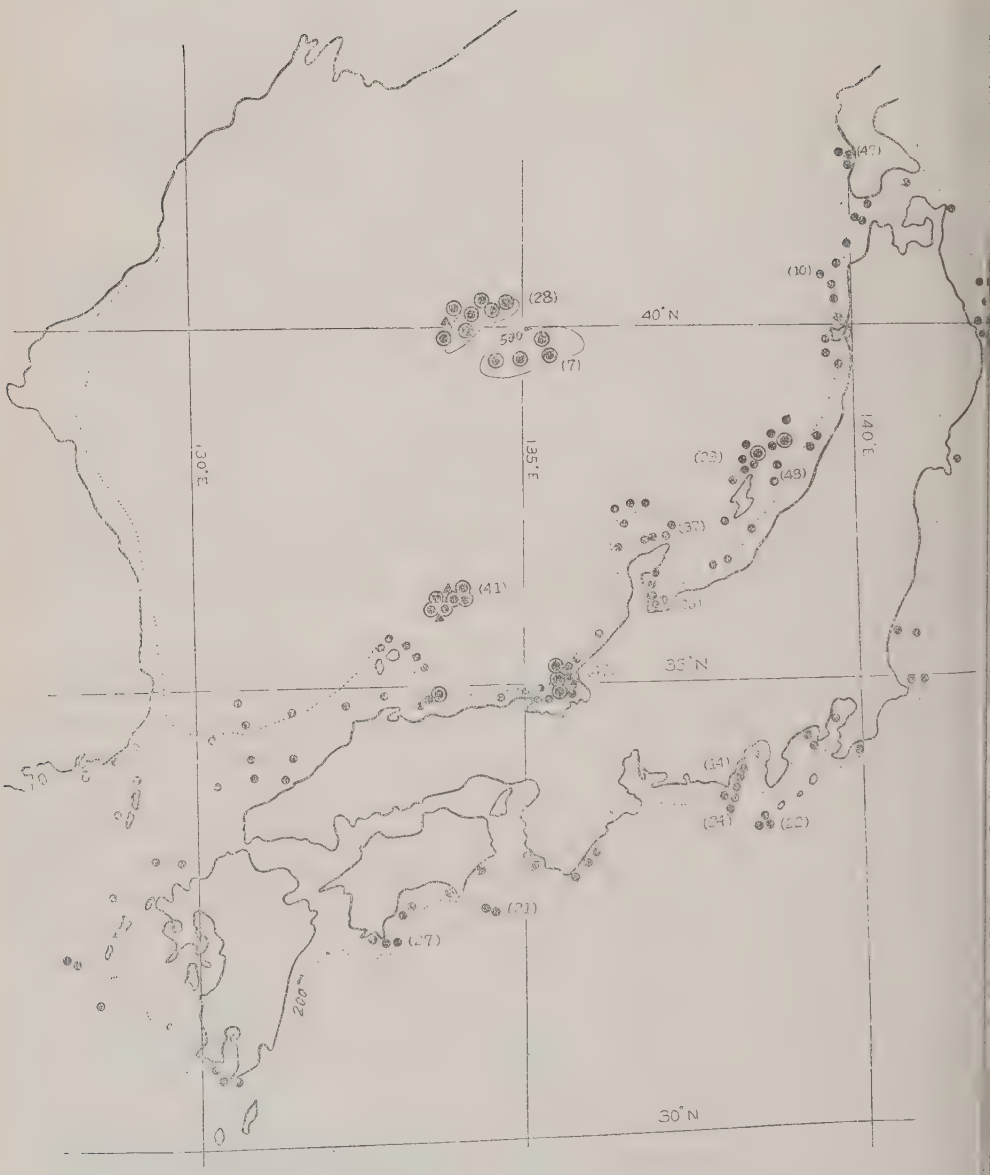

Fig. 2. Geographical distribution of gravel and distribution in depth.
● 100-400 m. ◎ 400–1,000 m. ▲ below 1,000 m.
note: See number 8, reference paper. (Arabic numerals are reference paper in which localities are described).

The result of the study on the size of the gravels dredged from the continental shelf shows an abnormal distribution: the size of gravel increases seaward as depth increases, except in the shallow area near shore or at the estuaries of large rivers.[31]

4) Sand and mud.:—

The distribution of sand and mud is limited by the depth and by the action of sea water, i, e, oceanic currents, tidal currents and waves. On the continental shelf, the distribution of sand and mud changes regionally, but in general it is present on the sea bottom below 200 m.

5) The mineral resorces of the continental shelf around the Japanese Islands.:—

Many coal fields and oil fields are present along the coastal region of the Japanese Islands. At some important coal mines, the galleries extend for more than two kilometres under sea floor. Where submarine coal fields are being mined detailed knowledge of the bottom configuration and bottom character are necessary for the safety of the coal mines and for future planning.

Form the result of surveys of the bottom charcter of the continental shelf adjuscent to known coal fields and oil fields of Japan, the author has gathered much evidencs of extension of the coal fields and oil fields under the continental shelf around the Japanese Islands. Figure 3 shows the distribution of the submarine coal fields and oil fields.

Fig. 3. An iedex map of the submarine coal fields and oil fields of the Japanese Islands.

Arabic numeralss refer to coal field.
Roman numerals refer to oil field.

1. Kushiro	I. Koitoi
1. Kuji	II. Wakkanai
3. Joban	III. Ishikari
4. Ube	IV. Ajigasawa
5. Ogura	V. Akita
6. Karatsu	VI. Yamagata
7. Sakito	VII. Teradomari
8. Matsushima	VIII. Sagara
9. Nagasaki	
10. Miike	

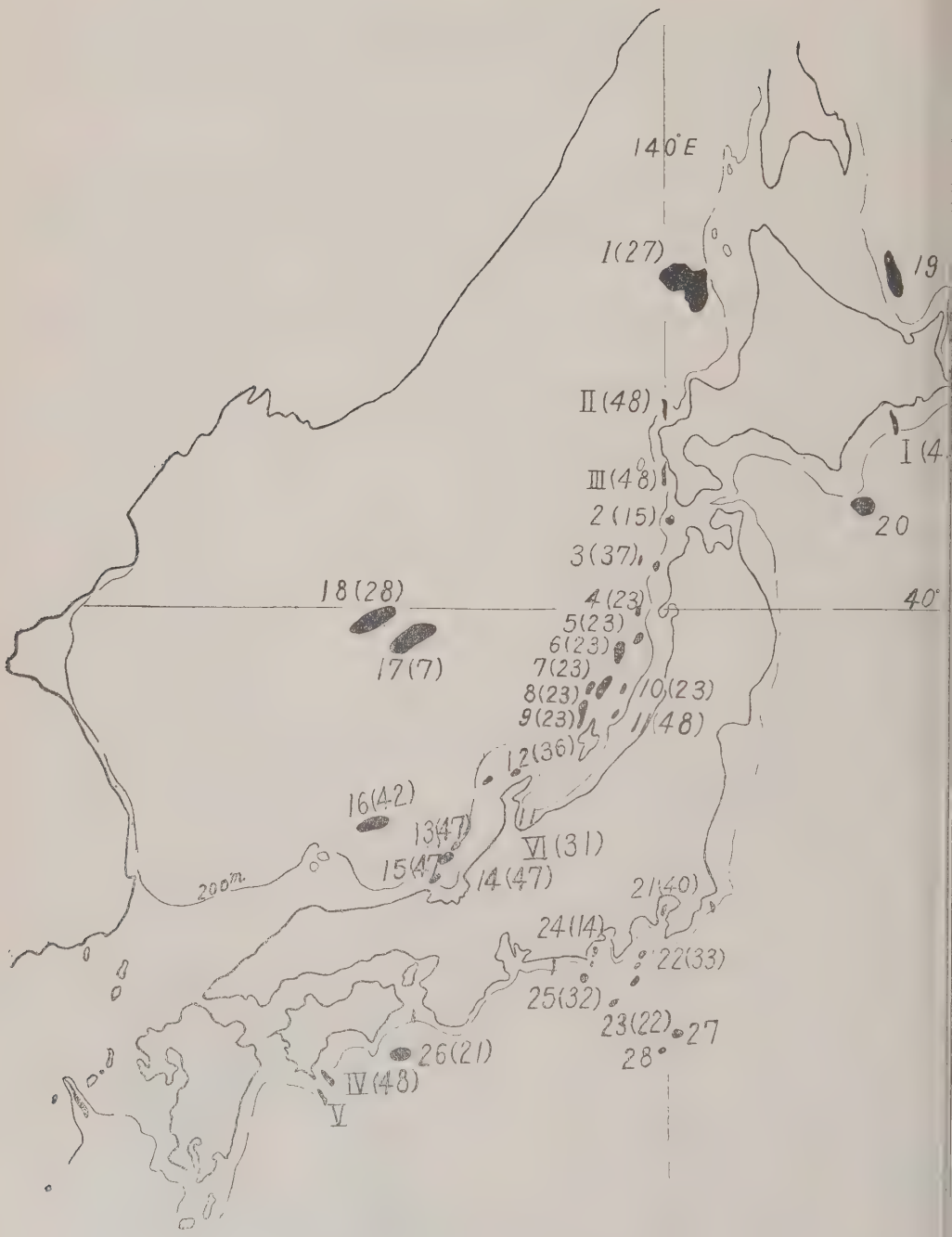

Fig. 4. Map showing the banks and submarine valleys. (Investigation finish) Arabie number refer to the number of the bank in in table III. (Arabie numerals) refer to the number of refered paper. Roman numerals refer to the number of the submarine valley in Table V.
(Arabie numerals) number of refered paper.

Table III. The name of Tectonic Banks and their bathymetric feature.

Sea	Number	Direction of axis.	Name of bank	Distance from land (Km.)	Name of nearest land	Area Outlined by 200m bathymetric line		Depth of the shallowest point (m.)	Depth of the bank surface (m.)	Bottom character			Number of published reference paper refered.
						Length (Km.)	Width (Km.)			( )··· Buried Rock	Gravel	Sand and Mud	
Japan Sea	1	NE—SW	Musashi tai	60.0	Teuri I.	30.0	10.0	31.0	140—160	+	+	+	29
	2	NE—SW	Nishitsugaru tai	94.0	Honshiu	8.0	5.2	95.0	120—140	+	+	+	15
	3	NE—SW	Kyurokushima	30.1	„	8.0	4.0	+5.4	120—140	+	+	+	38
	4	NE—SW	Oga Mukose	3.0	„	7.6	2.0	102.0	100—120	(+)	(+)	+	23
	5	NE—SW	Shin guri	5.5	„	7.5	3.5	140.0	120—140	(+)	(+)	+	23
	6	NE—SW	Mogami tai	40.0	„	30.0	10.0	133.0	140—160, 200—300	+	+	+	
	7	NE—SW	Mukose no Okinose	57.1	„	14.0	2.5	138.0	120—160	(+)	+	+	23
	8	NE—SW	Mukose	40.5	„	19.0	13.7	113.0	160—200	+	+	+	23
	9	NE—SW	Hyotan guri	41.4	Sado I.	28.0	7.0	102.0	120—140	+	+	+	23
	10	NE—SW	Chokaishyo	27.5	Honshiu	9.5	4.2	137.0	140—160	+	(+)	+	23
	11	NE—SW	Awashimashyo	2.1	Awashima I.	7.0	3.0	126.0	120—160	+	+	+	48
	12	NE—SW	Yomeguri	20.0	Honshiu	10.0	3.0	+0.8	20— 40	+	+	+	37
	13	NE—SW	Matsudashi	30.0		25.0	19.0	59.0	100—120	+	+	+	47
	14	NE—SW	Gentatsuse	30.0		18.0	6.0	10.9	100—120	+	+	+	47
	15	NE—SW	Urashimashyo	20.0		6.0	12.0	122.0	100—120	+	+	+	47
	16	NE—SW	Oki tai	140.0	„	100.0	20.0	282.0	300—400	+	+	+	42
	17	E—SW	Yamato tai	400.0	„	100.0	25.0	285.0	300—400	+	+	+	4
	18	E—SW	Kita Yamato tai	488.0	„	70.0	30.0	418.0	400—500	—	(+)	+	28
Okhotsk	19	E—S	Okhotsk Yamato tai	26.0	Hokkaido	50.0	7.0	138.0	130—200	+	+	+	
Pacific Ocean	20	E—W	Erimo tai	30.0	Hokkaido	30.0	15.0	153.0	150—180	+	+	+	
	21	NE—SW	Nakanose	10.0	Honshiu	5.0	8.0	16.0	16— 20	+	+	+	40
	22	E—W	Okinoyama	15.0	„	7.0	3.5	63.0	80—100	+	+	+	34
	23	NE—SW	Zenisu	30.0	Niijima I.	20.0	10.0	+2.0	120—140	+	+	+	32
	24	NE—SW	Senoumi	20.0	Honshiu	25.0	8.0	32.0	100—160	+	+	+	14
	25	N—S	Kinsunose	29.0	„	8.0	4.0	77.0	80—100	+	+	+	32
	26	E—W	Tosabae	50.0	Shikoku	31.0	15.0	154.0	200—400	+	+	+	21
	27	E—W	Shinkuose	45.0	Hachijo I.	10.0	2.9	16.0	140—150	+	—	+	
	28	E—W	Kurose	22.0	„	4.0	8.0	153.0	160—180	+	+	+	
	29	N—S	Kaitokushyo	70.0	Sulfer I.	1.0	2.0	180.0	190	+	—	+	33
	30	N—S	Umigatashyo	—	„	—	—	163.0	—	+	—	—	33

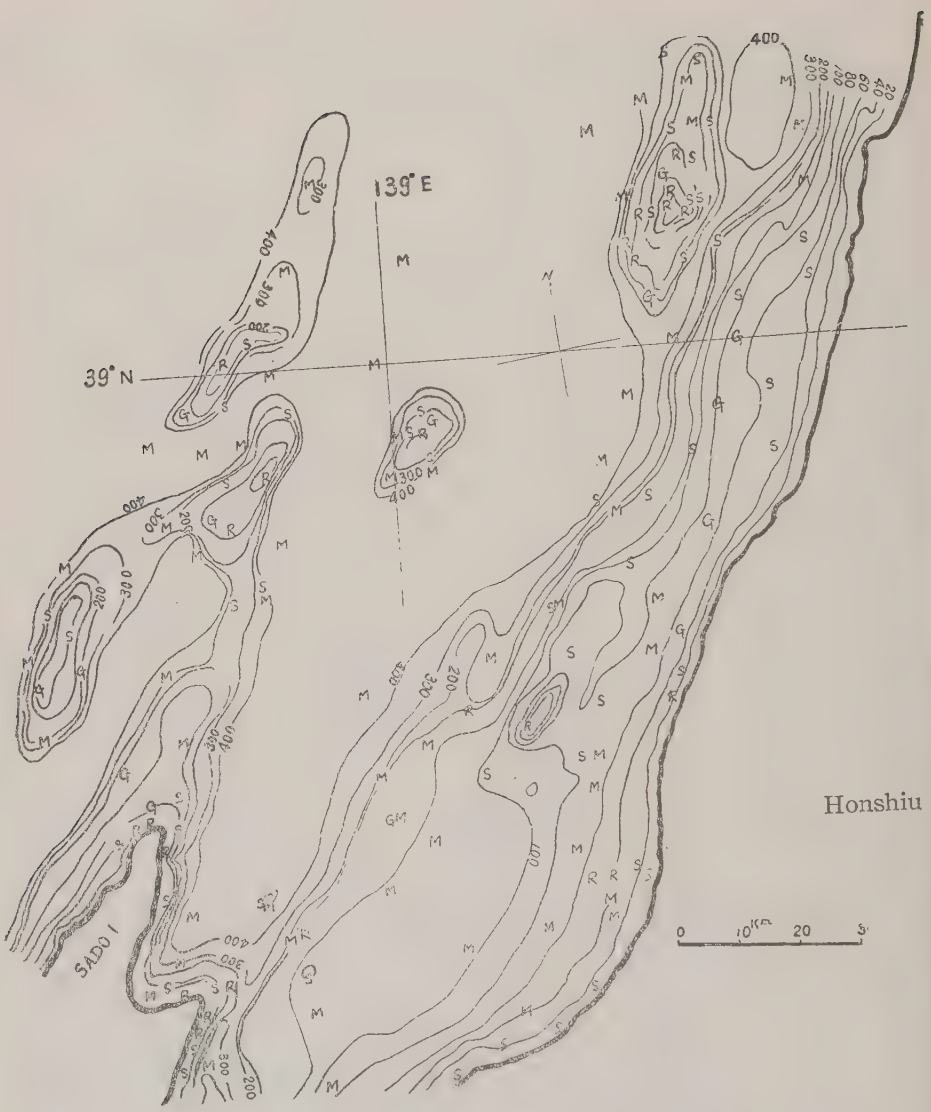

Fig. 5. Map showing the arrangement of the tectonic banks.

II. THE BANK.

1) The boottom configuration and distribution of the bank.

There are numerous banks on and near the continental shelf around the Japanese Islands. By their configuration and the arrangement, the bank can be classified in two kinds each distinctly different in geological origin.

2) Bank caused by tectonic movements.

Many islands and banks are aligned northeast-south west in the Japan Sea. They separated from the continental shelf of the Japanese Islands by a deep through. These belts of banks consist of several parallel[1,20] zones in which the depths of the tops of the banks increase step by step seaward from the Japanese Islands.

The banks are arranged in zones but when examined in detail, the axis of each bank is oblique to the main direction of its zone. This arrangement is a sort of echelon structure.

The bank of tectonic origin have a significant flat and broad top surface which at the margin descends abruptly to the deep sea floor, especially steep at the side faceing the continental shelf.

It is a notable fact that the depth of the flat plane on the banks along the continental shelf is within the limit of 140–160 m. and that the depth of the flat plane on the continental shelf is also 140–160m.

a) The bottam character.

The bed rock of the banks are exposed on the steep slope of the margin or on some part of the flat plane which is covered by gravels, sand, and mud.

The geological age ef the bed rock of the most of the banks is Tertiary as indicated by the fossils contained in them. There is one special case, the Tosabae bank,[21] where Pre-Tertiary rocks are exposed together with Tertiary rocks. Gravel dredged from the flat top surface of the banks, is large and the surface of the fragements well-waterworn. The rock type of the gravel varies from bank to bank. All the gravel dredged from the banks contained fragments derived from the bed rock.

The size of he sediments on and around the banks is far larger than the bottom sediments at the same depth on the adjuscent continental shelf.

b) Geological observations on the banks related to tectonic movement.

Judging from the configuration and bottom character, these banks are part of a tilted block which was isolated from the island after the deposition of Tertiary rocks and then submerged by the Post-Tertiary downward crustal movement or by the ustatic rise of sea level. The modification of the submarine configuration took place at the time or was closely related to the same action in the neighbouring continental shelf. There is on the continental shelf an abnormal distribution of gravel, of Pleistocene molluscs, of Peat, and of the remains of shallow sea mollnscs on the deep sea bottom. These facts may be closely related to the development of the flat surface of the continental shelf.

Table IV. The bottom characters of the Tectonic Bank

Number of bank	Base rocks of the bank			Gravel					Sand and Mud
				The largest piece of gravel on the bank					
	Rock character	Distribution in depth m.	Kinds of fossils contained in the rock	Rock character	Weight gr.	Length cm.	Rock characters of the gravels from the bank	Distribution of gravel in depth	
1	Diatom earth	65–206	Diatom	Basalt	41.0	5.2	Older R. Tertiary R. Volcanic R.	106–290	+
2	Tuff	267	—	Andesite	133.0	6.7	Older R. Tertiary R. Volcanic R.	86–364	+
3	Calcareous shale, Sandstone	28–320	Diatom, Foraminifera	Andesite	540.0	5.5	Tertiary R. Volcanic R.	18–173	
4	Calcareous shale	148	Foraminifera	Tertiary shale	30.0	5.0	Older R. Tertiary Rock	148	+
5	Calcareous shale	150	Foraminifera	Greywackesandstone	20.0	5.5	Older R. Tertiary R.	150	+
6	Sandstone shale	140–200	Foraminifera	Andesite	280.0	10.0	Older R. Tertiary R. Volcanic R.	154–343	+
7	Diatom earth, Sandstone	150–160	Diatom	Tertiary shale	17.0	6.0	Older R. Tertiary R	150–160	+
8	Diatom earth, Sandstone	20–117	Diatom	Greywacke sandstone	19.0	9.0	Older R. Tertiary R.	117–211	+
9	Diatom earth	454	Diatom	Basalt	83.0	5.0	Older R. Tertiary R. Volcanic R.	168	+
10	Diatom eatth	145	Diatom	Andesite	75.0	5.0	Older R. Tertiary R.	145	+
11	Calcareous shale	132–156	Foraminifera	Quartz porphyly	125.0	6.5	Tertiary R. Volcanic R.	132–156	+
12	Quartz-andesite	+8	—	Andesite	74.0	4.7	Older R. Teritary R. Volcanic R.	80–102	+
13	Shale, Sandston	114–237	Mollusca, Diatom	Greywacke sandstone	850.0	14.0	Older R. Tertiary R. Volcanic R.	77–466	+
14	Sandstone, Shale	76–239	Mollusca, Diatom, Plant leef	Liparite	310.0	8.9	Older R. Tertiary R. Volcanic R.	38–199	+
15	Shale, Sandston	110–190	Mollusca, Diatom	Quartzite	25.0	4.5	Older R. Tertiary R. Volcanic R.	59–322	+
16	Diatom earth	623	Diatom	Liparite	65.0	2.6	Older R. Tertiary R. Volcanic R.	277–1458	+
17	—	—	—	Andesite	1000.0	20.0	Older R. Tertiary R. Volcanic R.	340–460	+
18	—	—	—	Greywacke sandstone	23.5	4.7	Older R. Tertiary R. Volcanic R	464–1048	+
19	Calcareous shale, Sandstone	140–185	Foraminifera	Greywacke sandstone	35.0	6.0	Older R. Tertiary R.	140–455	+
20	Shale, Sandstone, Conglomerate	150–170	Sagarites (Sponge)	Andesite	153.0	22.0	Older R. Tertiary R. Volcanic R.	14–155	+
21	Shale, Sandstone	16– 25	Mollusca, Foraminifera	Clacareous shale	2.0	1.2	Older R. Tertiary R. Volcanic R.	16– 44	+
22	Tuff, Shale	91–164	Diatom, Foraminifera	Andesite	—	—	Volcanic R. Pumice	82–612	+
23	Propylite,	14–455	—	Coral	5000.0	28.0	Older R. Tertiary R. Volcanic R	55	+
24	Shale, Sandstone	77– 91	—	Greywacke sandstone	34.6	7.2	Older R. Tertiary R. Volcanic R.	51–261	+
25	Shale, Sandstone	269	Foraminifera	Calcareous shale	5.2	2.3	Older R. Tertiary R. Volcanic R	269	+
26	Shale, Sandstone	16– 25	Mollusca, Foraminifera	Calcareous shale	2.0	1.2	Older R. Tertiary R. Volcanic R.	16– 44	+
27	Sandstone	91–164	Diatom, Foraminifera	Andesite	—	—	Pumice	82–612	+
28	Tuff breccia		Mollusca, Foraminifera	—	—	—	—	—	+
29	Andesite, Calcareous Sandstone	189–200	Foraminifera	—	—	—	—	—	+
30	Liparite	160	—	—	—	—	—	—	+

Rock character of gravel. Older rock: Greywrackesandstone, Chert Quartzite, Slate, Granite etc. Tertiary rock: Sandstone, Shale, Conglomerate
Pliotocene rock: Shale, Calcareous Sandstone, etc.

				Off Ashizuri P., Shikoku	Off Zintsu River, Toyama
The mane of submari				Off Ashizuri P., Shikoku	Off Zintsu River, Toyama
The side of the conti				Tosa Bay, Pacific coast	Toyama Bay, Japan Sea.
Topography	The connected val			—	Zintsu river
	The coaurse of va			Meander	Meander
	The width at the			3.2 km.	2.0 km.
	The length of vall			5.0 km.	5.0 km.
	Tuributary			Abundant	Rare
	The steepest angel			18°47′	25°00′
	Depth of terrace i			300 m.	—
	Depth of the flat			120—160 m.	20—40, 120—160m.
	Depth of the head			160 m.	20 m.
	Depth of the begi			1.000 m+	800 m.
Bottom character	At valley wall	Rock	The dis	190—276 m.	100—160 m.
			The co	Exposed	Exposed, Buried
			Rock cl	Shale, Sandstone	Sandy shale, Tuff.
			Fossil i	Foraminifera, Mollusca, Plant	Sponge spicule
			Geologi	Tertiary, Pleistocene	Tertiary
		Gravel	The dis	276—300 m.	80—200 m.
			The co	Exposed, Buried	Exposed
			Rock ch	Tertiary, Pleistocene	Older rock, Tertiary, Volcanic, Pleistocene
			The largest gravel at a station	Exposed, Buried	Exposed
				Shale	Greywacke sandstone
				2.0 gr.	139 gr.
				3.7 cm.	7.3 cm.
		Sand and mud		+	+
	At valley center	Rock		—	—
		Gravel		+	+
		Sand and mud		+	—
	Continental shelf at the flat plane	Rock	Rock	Sandstone, Sandy shale	Tuffaceous sandstone, Peat.
			Geolog	Tertiary, Pleistocene	Tertiary, Pleistocene
		Gravel		+	+
		Sand and mud		+	+
Number of published				48	31

Classification	Example
A. The course of the Valley.	
a. Meander	The submarine valley off Kushiro.
b. Straight	The svbmarine valley off Esashi.
B. The depth of the lower limit of valley.	
a. Valleys which show distinct form on the ocean bottom deeper than 2,000m.	Many are found on the Pacific side of Japan: the submarine valleys off Kushiro, Tokyo, Ashizuri etc.
b. Valleys which show distinct form at the depth of about 800m.	Many are found on the Japan Sea side of Japan.
C. The depth of the valley head.	
a. The valley head reaches to the flat plane of 160m.	Many are found on the Pacific side of Japan: the submarine valleys off Kushiro, Chyosi, Tokyo, Ashizuri etc.
b. The valley head reaches to about 20m.	Many are found on the Japan Sea side of Japan.
D. The relation between submarine valley and valleys on land.	
a. The heads of the submarine valleys connect to valley on land.	Submarine valley off Zintsu River, Japan Sea, and off Sutsu, west coast of Hokkaido.
b. The heads of the submarine valleys do not connect to valley on land.	Submarine valley south east off Ashizuri Peninsula.

According to the records of echo sounding, traverses section of submarine valleys are V-shape without exception and often asymetrical. The slope of the valley is steep, sometimes exceeding 40 degrees.

The submarine valley are broad but deeply incised having very steep walls.

Those features closely resemble those of canyons on land. At the upper reaches of the valleys, both on the Pacific and Japan Sea coast, the tributaries branch off at the depth of 300 m. and cut into the continental shelf. Their features are the same as those of main valley.

It is notable that there is a reverse of gradient at the upper reaches of the submarine valleys where strong oceanic currents flow cross their coauses; for exsamples: submarine valley off Shimanto River and off Tokyo Bay.

Additlonally there are found flat steps on the submarine valley walls which resembles river terraces; examples are found in the submarine valleys at Kushiro and Shimanto River.

2) The bottom character of the submarine valleys.

Dredging has revealed that Tertiary rocks are exposed on the steep walls of all of the submarine valleys, without exception. In some submarine valleys, Pleistocene deposits are exposed on the steep wall near the head of the valley and on the terrance scarp in the valley. At the south coast of of Shikoku, Pleistocene deposits are spread on the contintneal shelf at the depth of 120–180 m. where the head of the submarine valley terminates at that depth.

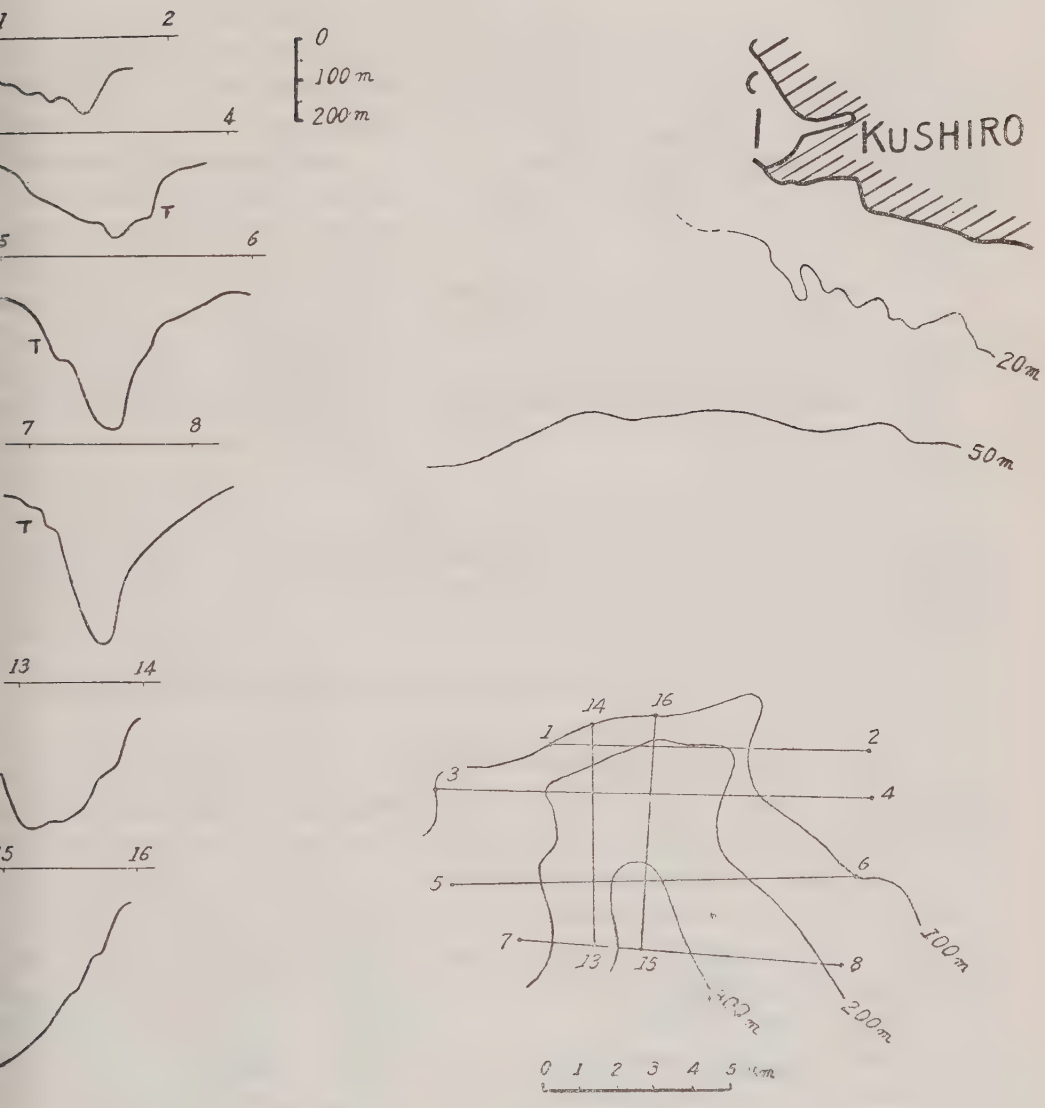

Fig. 6. An example of submarine valley.

Right Side: Bathymetric map of Kushiro submarine valley.

Left Side: 1-8. The record of transversal section by echo sounding. T. : Terrace in the submarine valley.

: 13-16. The longitudinal section by echo sounding.

Gravels are distributed on the gentle walls of the submarine valleys. Sand anb mud are distributed on the gentle wall, and in the bottom of the valleys.

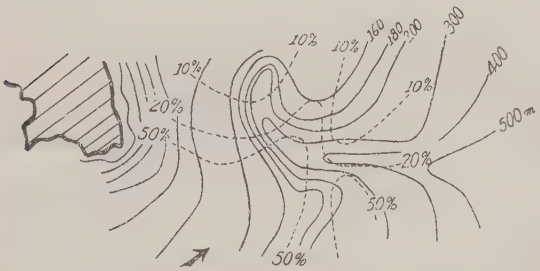

Fig. 7. The relation between recent deposit and bottom configuration, → means the direction of strong current

Fig. 7.a. The distribution of the percentage of sand (2.0–0.07 mm) in the bottom deposits around submarine valley off Shimanto River, Shikoku

The distribution of the size grades of sand or mud are very interesting[31,48] The result of the mechanical analysis on the sand and mud which are dredged from the sea bottom around the head of the submarine valley at Zintsu River, Toyama Bay and Shimanto River, Shikoku are especially interesting, The boundary line of the distribution on size grades crosses the caurse of the submarine valley.

The direction of this boundary line is the same as that of the strong current that crossess the sumbarine valley; it is concluded that the head of the sumbarine valley is filling up with sand or mud which are transported by the strong cuurrent.

3) The relation between the submarine valley and the continental shelf.

Some submarine valleys have engraved their caurses into the 20 m. flat plane (Terrace?) which in some places is composed of buried forests. The geological age of peat or buried forests as interpreted from the contained plants seems to be late Pleistocene or early Alluvium. Therefor, the cutting of the submarine valleys continue until that time or latter. The heads of the submarine valley at Zintsu River, Toyama Bay or Sutsu, Hokkaido may be late Plistocene or early Alluvium.

The head of the submarine valley of Pacific side do not cut into flat plane of 120–180m. from which Pleistocene deposits have often been dredged. Pleistocene deposits have been dredged from steep walls at the upper reaches of submarine valley and from the terraces in the submarine valleys. There-

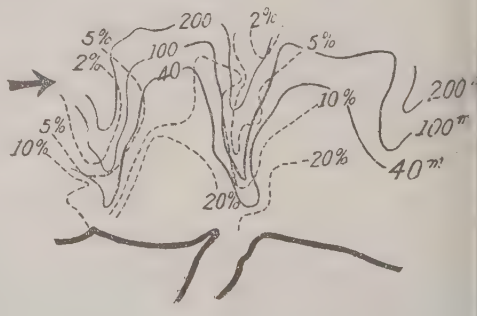

Fig. 7.b. The distribution of the percentage of sand (1.0–0.05mm) in the bottom deposits around submarine valley off Zintsu River, Toyama Bay.

fore, the submarine valleys existed before Pleistocene time and were buried after the times when 120–180m. flat plane on the continental shelf started to be build and burial continues to recent time.

Tertiary rocks have been dredged from steep walls of the submarine valleys at the margin of the continental shelf. It seems that the cutting of the upper part of the submarine valley begins after the construction of the continental shelf which is composed of Tertiary rocks. The lower course of the submarine valley reaches to depth below 2000 m. but the author has not obtained botton samples from such depths, so the time of initation of the valley cutting is not known. The submarine valleys at Shimanto River, off Shikoku are as descrived above.

4) The oceanic condition of the submarine valley.

Oceanographic investigations in the submarine valley reviled no shifting of sea water through the valley strong enough to cut the valley.

5) Marine life in submarine valleys.

In the submarine valleys, marine life is not rich in both species and individuals except on rocky bottoms. In some valleys there live peculiar organism such as the "firefly cuttle fish" which is a notable product of the submarine valley of Toyama Bay. The margin of the submarine valleys and the bottom of the tributaries which cut the continental shelf are the good fishing grounds for deep sea fishes.

IV. CONCLUTION.

Many banks and submarine valleys exist on and around the continental shelf of the Japanese Islands. These banks and valleys on the sea bottom provide important fishing grounds and are of special interest to oceanography, zoology and geology.

The author surveyed these banks and valleys during the years 1930–1952 and collected bottom materials from them and made oceanographic observations at their sites.

Study of the field data and collected samples led the author to the results mentioned above.

The banks and submarine valleys exhibit notable peculialities in submarine configuration, bottom deposit, and fauna when compared to the continenal shelf.

From the geological point of view, topography and geology of these areas present many problems whose solution will help clarify the geological structure and the geological history of the Japanese Islands.

V. ACKNOWLEDGMENT.

The author express his sincere thanks to late Prof. Takeo Kato of the Tokyo University who gave me continuous encouragement.

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PLATES

PLATE I.

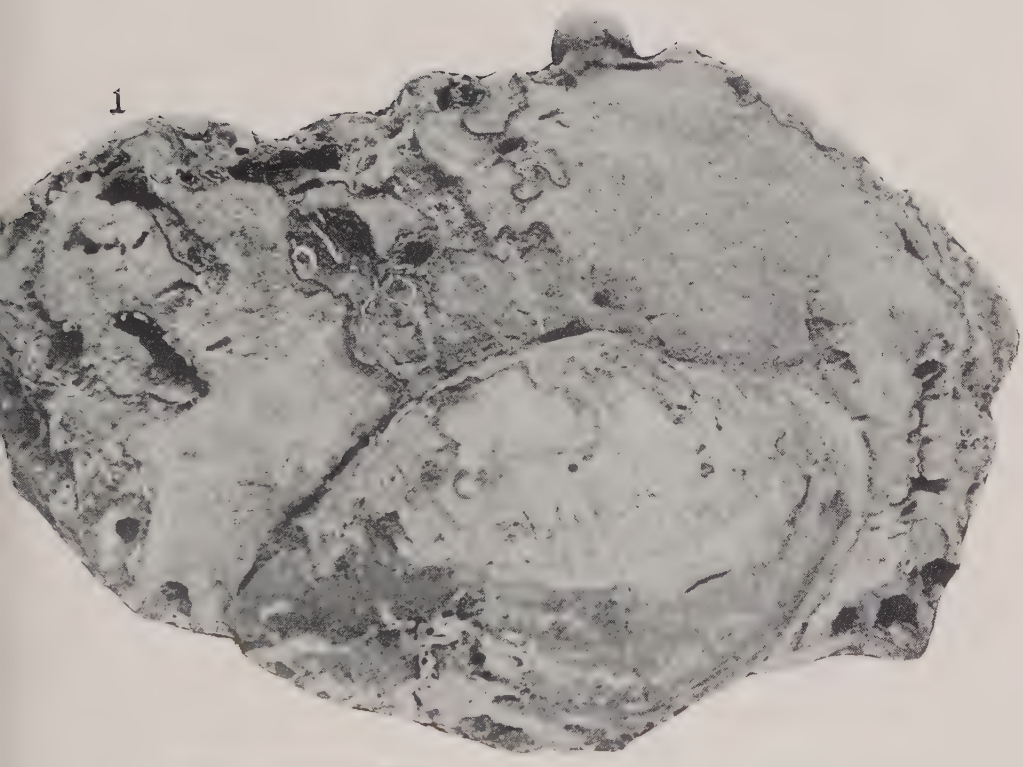
Fossils dredged from sea bottom.

Fig. 1. *Paphia schnelliana* (Dunker) internal mould.

Fig. 2. External cast of the above fossil

Rock: Calcareous sandstone
Geological age: Young Tertiary.
Locality: South east off Ashizuri Peninsula at the margin of continental shelf. 32° 37.8′ N. 133° 06′ E. 200 m.

1



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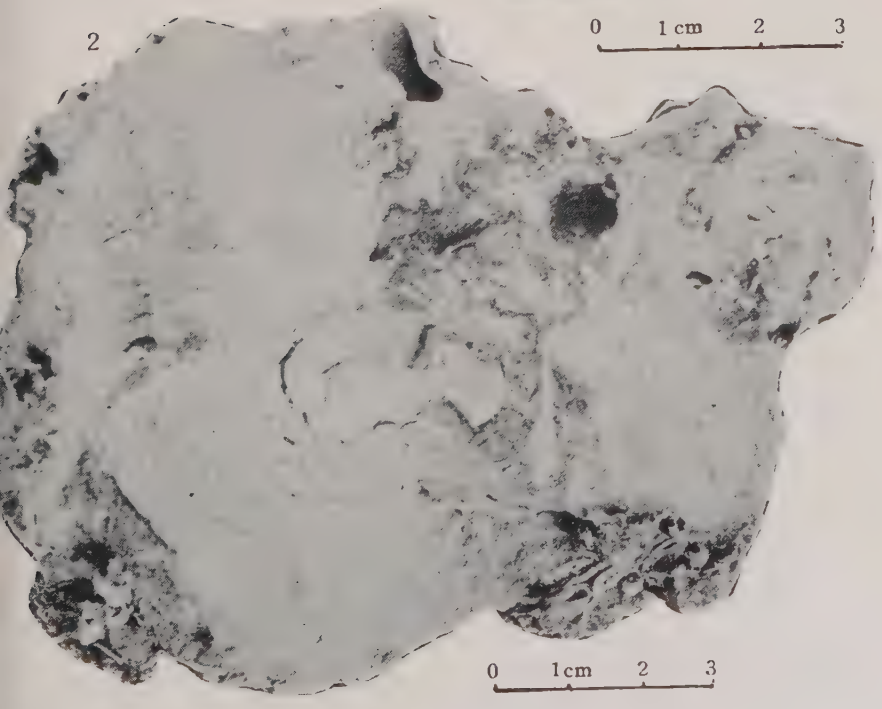

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PLATE II.

Fossils dredged from continental shelf.

Fig. 1.2.3. *Carcinoplax longimanus* (de Haan)

1. Fossil crab in calcareous sandstone. (Calapace and abdomen)
   Locality: 32° 37.8′ N. 133° 05′ E. 200 m.
   Off Ashizuri Peninsula, Shikoku, Pacific coast.
   Geological age: Young Tertiary.
2. Separated fossil crab dredged frem sea bottom.
   Locality: 32° 20′ 30″ N. 133° 30′ 20″ E. 251 m.
   Off Kôchi, east coast of Shikoku, Pacific coast.
3. Calapace of fossil crab.
   Locality: 33° 09′ 10″ N. 133° 30′ 20″ E. 251 m.
   East of Ôsumi strait

Fig. 4.5. *Serripes lapesourii* (Deshayes) in the rock fragment dredged from sea bottom.
   Geological age: Young or middle Tertiary.
   Locality: 39° 22′ 50″ N. 128° 00′ 36″ E. 300 m.
   Off Genzan, Korea.

6. *Mya* sp. This fossil dredged together with Fig. 4.5.

Fig. 7—12. Separated fossil molluscs dredged from Korean Strait.
   34° 59′ 40″ N. 130° 31′ 00″ E. 139 m.

7.8. *Corbula venusta* Gould.

9. *Puncturella* sp.

10. *Pyrene* sp.

11.12. *Olivella flugurata* Ad. et Rve.

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PLATE III.

Fossils dredged from sea bottom

Fig. 1. *Thyasira bisecta* Conrad in the soft deposits. Preservation is very good, cuticula layer existed, looks very fresh.
Geological age: Tertiary?
Locality: East part of Korean Strait.
35° 37' 00" E. 131° 02' 00" E. 246 m.

Fig. 2.3. *Thyasira bisecta* Conrad *var. nipponica* Yabe et Nomura. Preservation is very good and looks fresh. This specimen obtained from the concretion shown in Fig. 7. dredged on the insular shelf of Tobishima Island, Japan Sea.
Depth: 200 m.
Geological age: This kind of fossil is found in the Neogene Tertiary in Japan.

Fig. 4.5. *Nucula mirabilis* Ad. et Rve. These specimens are separated fossils in the sand, but well petrified.
Locality: 30° 55' 00" N. 131° 03' 50" E. 154 m. East part of Ôsumi Strait.

Fig. 6.7. *Lucina actilineata* Conrad. Shells are gathered in a concretion dredged from insular shelf of Tobishima Island.

Fig. 8. Calcareous shale dredged from 39° 22' 05" N. 139° 35' 40" E. 139 m. The surface is bored by organisms. Contains many micro fossils such as forminifera and sponge spicules.
Geological age: Young Tertiary.

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PLATE IV.

Fossils dredged from sea bottom

Fig. 1—4. *patinopecten (pecten) tokyoensis* Tokunaga. *patinopecten tokyoensis* Tok. is a characteristic fossil of Pleistocene in Japan.
These specimens were dredged from the continental shelf of south west coast of Japan. They were found in soft deposits and the preservation of the shell is very good. Some samples preserve the shell colors and appear very fresh.

1. 32° 45' 00" N. 132° 23' 30" E. 210 m.
2. 31° 05' 45" N. 131° 14' 35" E. 117 m.

3,4 33° 35' 35" N. 135° 18' 00" E. 162 m.

Fig. 5. A fragment of fossiliferous soft rock dredged from 32 26'. 7 N. 133°05'.7 E. 276 m, on the terrace of the submarine valley off Ashizuri Peninsula, Shikoku.

Fossils are:

Acila divaricata (Hinds)
Limopsis tajimae Sowerby
L. crenata A. Adams
Yoldia sp.
Chlamys sp.
Mitrella bicinctella (Yokoyama)
Cavolina sp.
Minola sp.
Dentalium sp.

Geological age: Pleistocene

PL. IV.

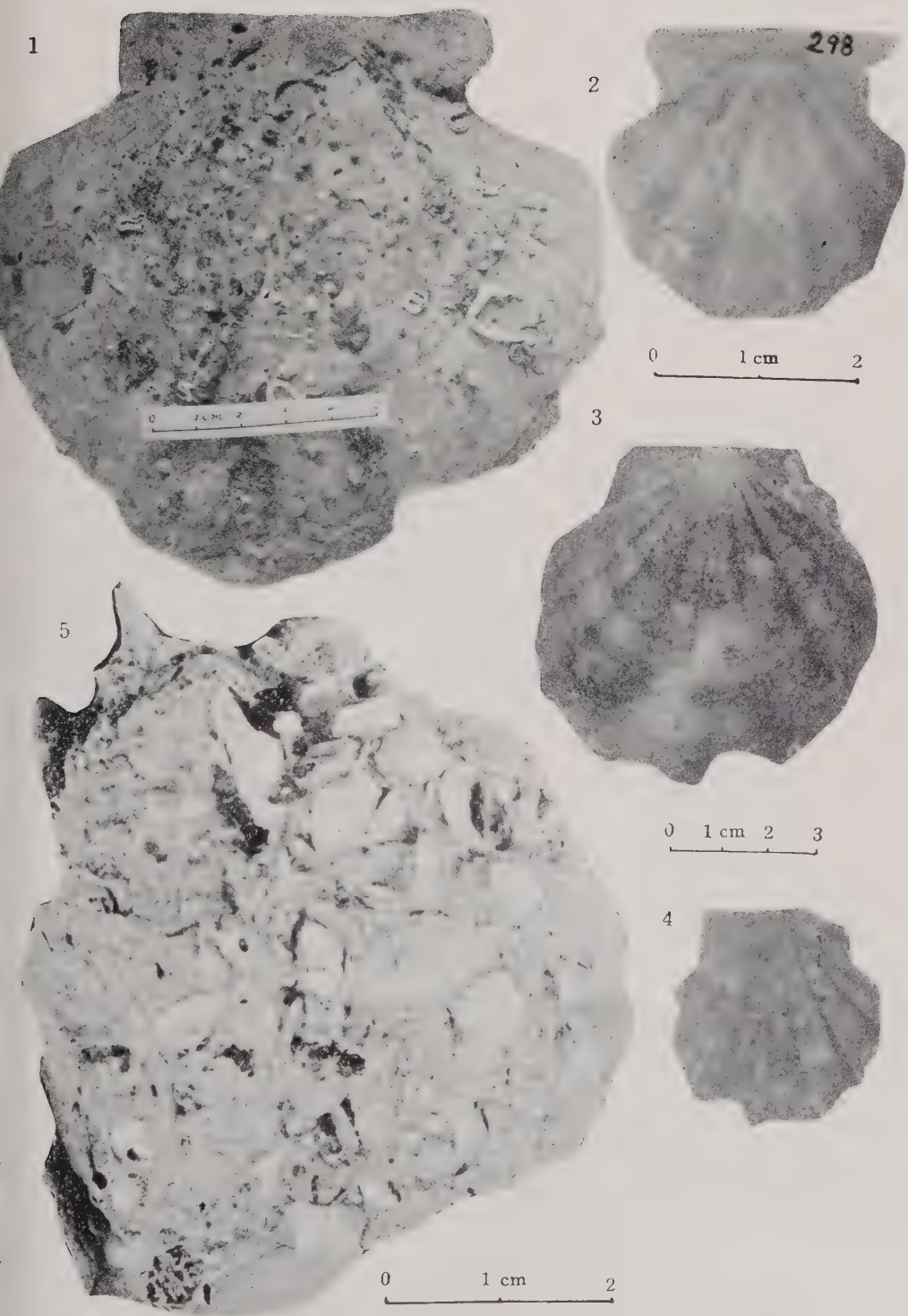

PLATE V.

Fossils dredged from sea bottom.

Fig. 1—5. Shells of shallow sea molluscs dredged from deep bottom at 30° 55" 00" N. 131° 03' 50" E. 154 m., Ôsumi Strait, Pacific coast.

1. 2. *Ostrea gigas* Thumberg.
3. 4. *Meretrix meretrix* L.
5. *Rapana thomasiana* Crosse.

Geological age: Pleistocene.?

Fig. 6. Fossil *Limopsis tokaiensis* Yokoyama dredged from 32° 41.6' N. 133° 09.7' E 448 m. From the steep wall of the submarine valley off Shimanto River, Shikoku, Pacific coast.

Geological age: Youdg Tertiary.?

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PLATE VI.

Sand-pipe and Gennôishi (Pseudomorph of calcite) dredged from the sea bottom.

Fig. 1. Sand pipe dredged from 37° 39.8' N. 133° 06' E. 200 m. Many fossil crabs were obtained from the bed rock at the same station.

Fig. 2.,3 Gennôishi (Psendomorph of calcite) dredged from 39 10' 56" N. 128° 00' 28" E. 300 m., off Genzan, east coast of Korea. Japan Sea. Tertiary molluscan fossils were dredged from the same station.

2. Photo of side that rested on the sea bottom.
3. Photo the opposite side.

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0 1cm 2 3

PLATE VII.

Fig. 1. 2. 3. Photomicrographs of thin sections of Tertiany rocks. These rocks belong to the same geological horizon.

1. Calcareous shale containg diatoms and foraminifera which was deposited at Iwasaki Mura, Nishi Tsugaru Gun, Aomori Prefecuure, near Kyurokushima.
2. Calcareous shale containing diatoms and forminifera dredged from Danshichine at the opposite continental shelf near Kyurokushima Island. 40° 27' 50" N. 139° 40' 20" E. 150 m.
3. Calcareous shale containing diatoms and foraminifera dredged from continental shelf near Kyurokushima. 40° 39' 00" N. 139° 49' 10" E. 162 m.

Fig. 4. Tertiary rocks dredged from Tosabae Bank off Muroto Persimsula, Shikoku, Pacific coast. 33° 02' 00" N. 134° 48' 25" E. 269 m. Many fossil foramifera are contained in the rock.

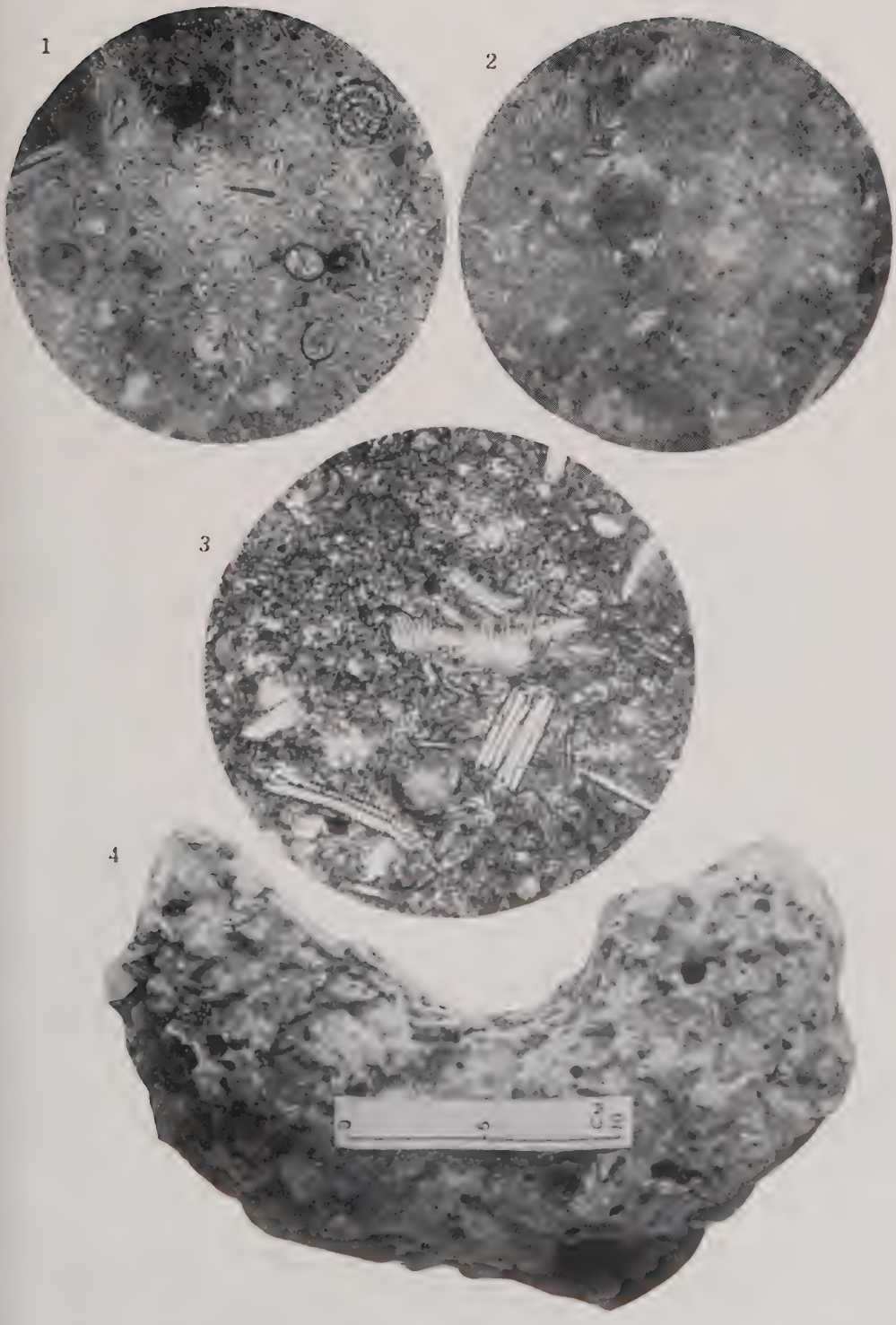
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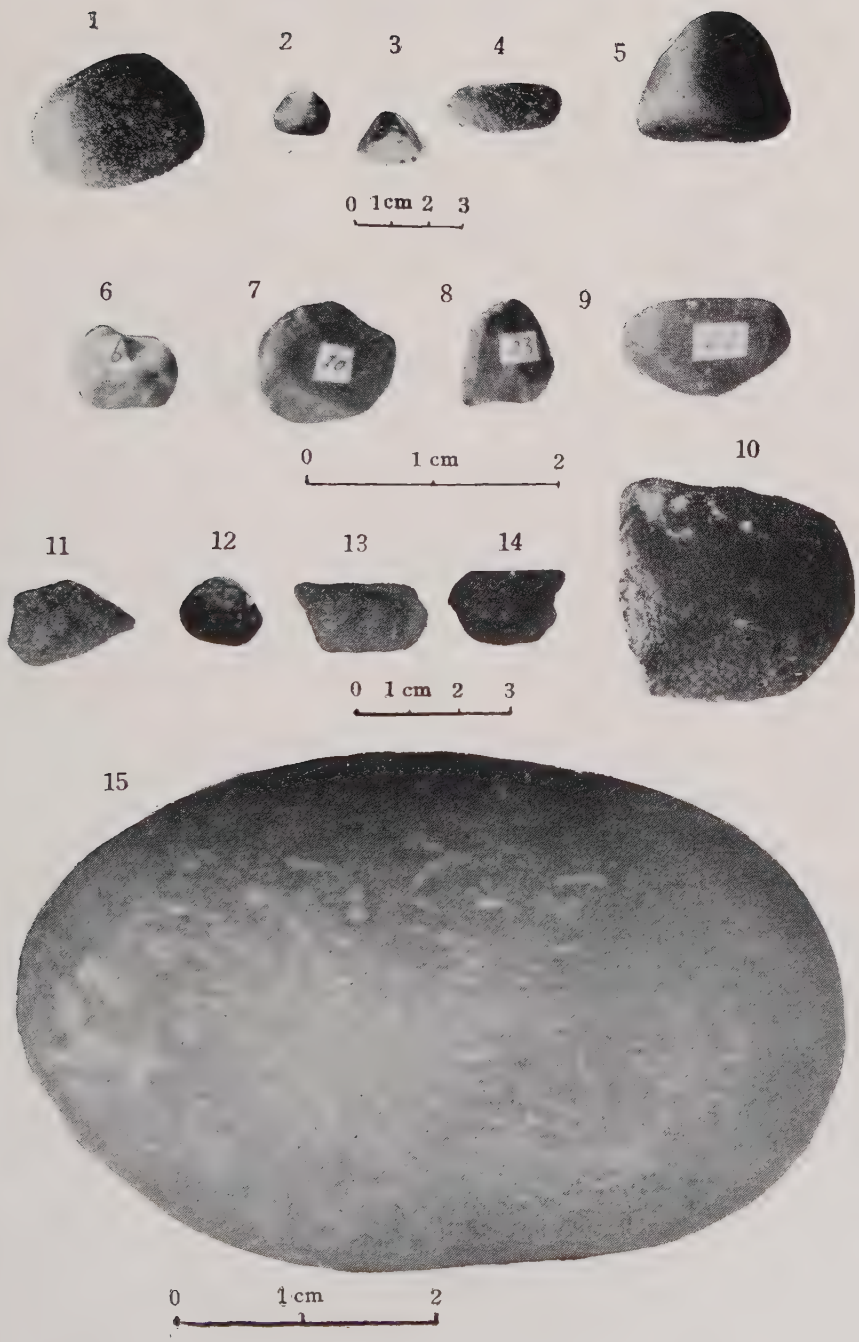
PLATE VIII.

Gravels dredged from banks.

Fig. 1—5. Gravel dredged from Yamato Tai Bank, Japan Sea.
1. Chert 2. Greyweacke sandstone 3. Sandy shale 4. Andesite
5. Shale
39° 08′ 05″ N. 135° 20′ 00″ E. 330 m.

Fig. 6—14. Gravel dredged from Kita Yamato Banks, Japan Sea.
6. Liparite 39° 45′ 15″ N. 133° 37′ 00″ E. 526 m.
7. Liparite 39° 49′ 00″ N. 133° 42° 05″ E. 535 m.
8. Chert 39° 52′ 30″ N. 133° 40′ 30 E. 655 m.
9. Biotite granite 39° 49′ 20″ N. 133° 40′ 00″ E. 545 m.
10—14. Biotite granite 39° 52′ 30″ N. 133° 44′ 35″ E. 453 m.

Fig. 15. Gravel dredged from Erimo Bank, Hokkaido.
41° 38.′3 N. 143° 37.6′ E. 170 m.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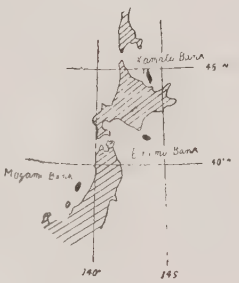
ON THE BOTTOM CHARACTER OF SOME NEW BANKS IN THE WATERS NEIGHBOURING THE JAPANESE ISLANDS.

By

Hiroshi NIINO

(With plate I–II)

1. Introduction.
2. Mogami Bank, Japan Sea.
3. Okhotsk Yamato Bank.
4. Erimo Bank, Pacific Coast of Hokkaido.
5. Conclusion.



New discovered Bank.

I. INTRODUCTION.

During the year 1947, the Hokkaido Fisheries Experimental Station, Hydrographic Office, Tokyo University of Fisheries investigated the continental shelf around the Japanese Island and its vicinity for the purpose of discovering new fisheries grounds. Three banks were discovered in this survey *i. e.* Mogami Bank near Tobishima Island, Japan Sea, Okhotsk Yamato Bank off the coast of Hokkaido, and Erimo Bank off Erimo Peninsula on the Pacific coast of Hokkaido.

These banks are valuable fisheries grounds and are also of importance in the solution of geological problems of the Japanese Islands.

II, MOGAMI BANK.

Mogami Bank is situated at 39° 00' N–39° 36' N, 138° 40' E–138° 00' E, and is oriented in a northeast-southwest direction. The sea bottom is more than 800 m. deep between continental shelf of Japan and Mogami Bank. The shape outlined by the 500 m. bathymetric line is that of an ellipse having a long diameter of about 100 km. and a short one of about 30 km. The top of the bank is a significant broad and flat plane at a depth of 300-200 m. The shallowest point is 133 m. at the south, 136 m. at the north. The margin of the bank abruptly decends to a deep floor. The gradient of slope is very steep on the side facing Honshiu and less steep on the opposite side. This is characteristic of the banks in the Sea of Japan such as Mukose bank, Chokaishyo, Hyotan guri and in the neighbouring banks.

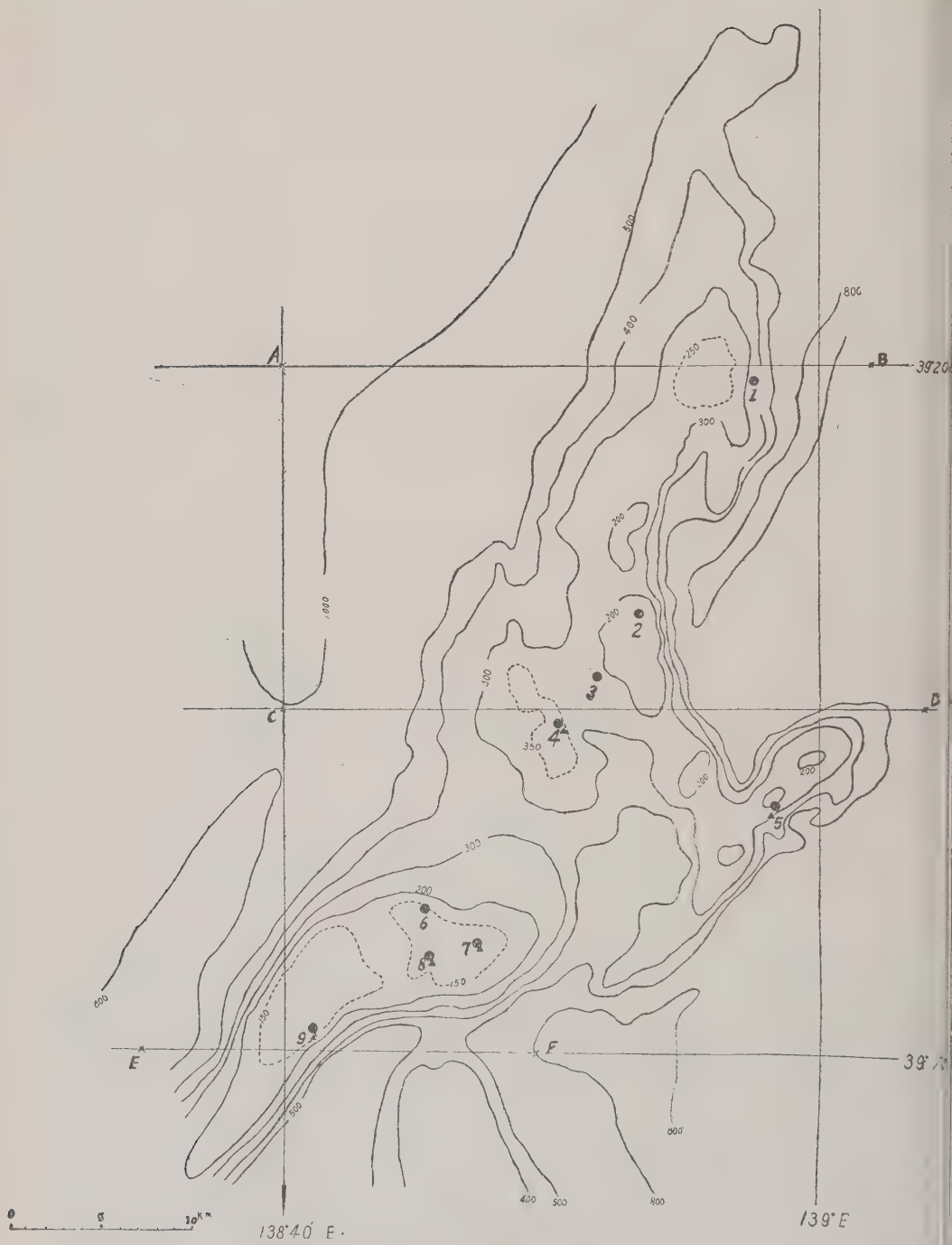


Fig. 1. a. Mogami Bank, Japan Sea

● Dredged station ▲ Locality of bed rock.

Fig. 1. b. Section of Mogami Bank.

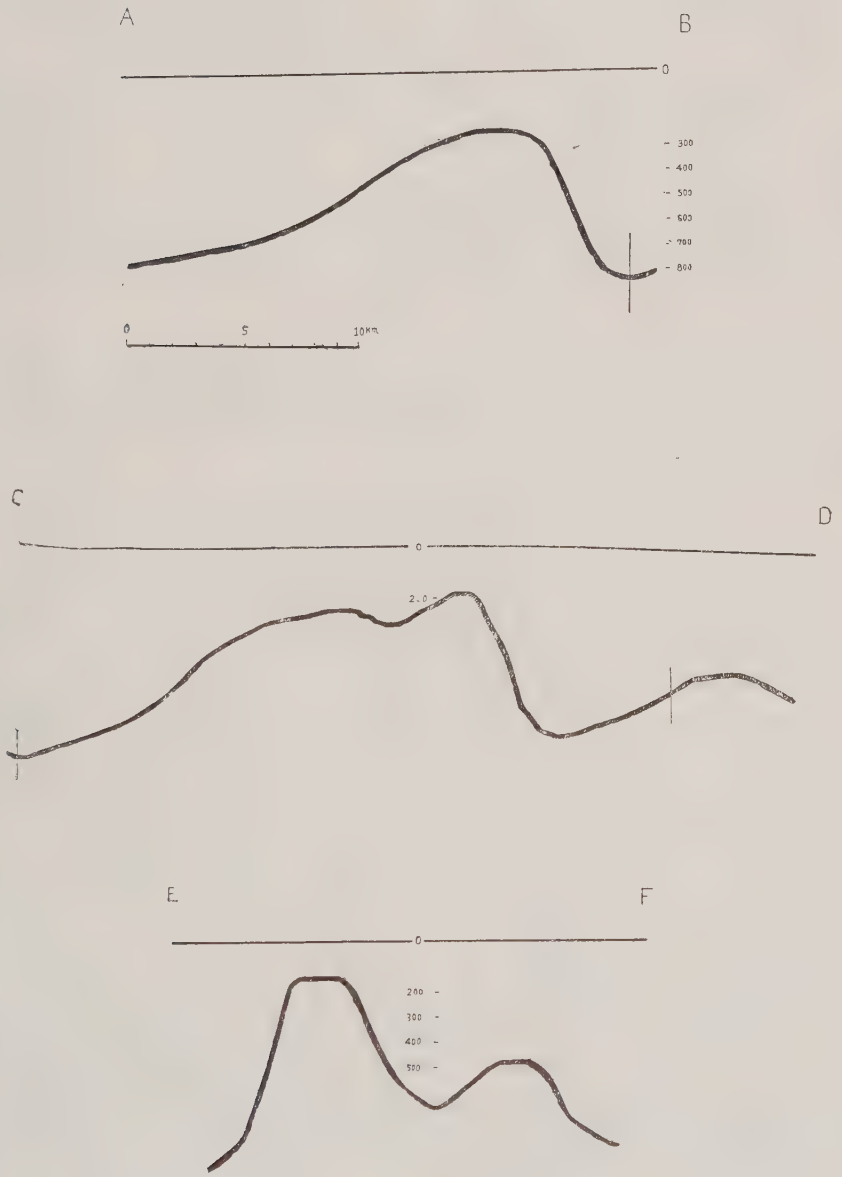


Table I. Dredge station and bottom character at Mogami Bank.
A: Abundant, R: Rare

Station	N. Latitude	E. Longitude	Depth m.	Bottom deposit				Date of collection
				Rock	Gravel	Sand & Mud.	Organic remain	
St. 1	39°19.4′	138°57.9′	265		A	A	R	1948. Aug. 14
2	39 13.4	138 54.0	343		A		R	1950 Aug.29
3	39 10.8	138 51.8	240		A	A		1950 Aug.29
4	39 09.4	138 56.1	170	A				1948 Aug.16
5	39 07.0	138 59.1	200	R			R	1948 Aug.16
6	39 04.2	138 45.0	140		A	R		1948 Aug.18
7	39 03.3	138 47.1	154	R	A		R	1948 Aug.17
8	39 03.8	138 45.8	140	A			A	1948 Aug.18
9	39 01.6	138 41.8	140	A		R		1948 Aug.18

1. Bottom character. (Table I)

Bottom materials were obtained from 9 stations by the Daishi Kaiyomaru of the Hydrographic Office. The collecting apparatus used were snapper and tube bottom collector.

Table II. Rock fraganents dredged from Mogami Bank

Station	Depth.	Weight	Length	Width	Thickness	Organisms or Bored hole	Kind of rock	Position
	m.	g.	cm.	cm.	cm.			
St. 4	170	1.5	2.4	1.4	1.4	+	Diatom earth	Center of flat plane
St. 5	200	0.5	1.2	0.9	0.8	+	Dia omaceous shale	East slope, central part.
St. 7	154	0.2	1.0	0.6	0.4	+	Tuffaceous Shale	South flat plane
St. 8	140	10.0	4.5	3.0	2.1	+	Diatomaceous shale	„
St. 9	140	23.0	5.8	4.0	2.6	+	Diatomaceous shale	„

a. Rock fragments. (Table II)

Rocks were dredged from five stations. The surface of the rock were bored by organisms and many organisms attached on the surface; therefore, the rocks are believed to have been exposed on the sea bottom. The kinds of rock recovered are: diatom earth, diatomacious shale, the various kinds of rocks in the Tertiary system of northeast Honshiu that are often dredged from the banks in the Japan Sea.

The stations at which rock fragments were dredged are located on the flat plane or steep slope of the bank. At some stations, gravel, sand and mud were dredged together with rock fragment indicating that gravel or sand and mud have been deposited on the rocky bottom.

Table III. The measurement of the largest gravel at each station on the Mogami Bank

Station	Depth.	The largest price of gravel								Rock character of associated gravel	Position
		Weight	Length	Width	Thick-ness	Shape	Surface	Adhesion of organism	Rock character		
	m.	gr.	cm.	cm.	cm.						
St. 1	265	5.9	2.3	2.3	0.95	Round	Smooth	+	Andesite	Chest. Andesite	North slope
2	343	11.0	2.5	2.2	1.3	Sub R.	Smooth	+	Andesite		East slope
3	240	250.0	10.8	10.5	4.5	Sub R.	Irregular	+	Liparite	Greywacke, Liparite	Center
5	200	0.2	0.6	0.5	0.4	Angular	Shale	+	Shale	Shale, Andesite	East center
7	154	0.5	0.6	0.4	0.25	Round	Smooth	+	Sandstone	Sandstone. Andesite	South end

Table IV. Dredged station and bottom character at Okhotsk Yamato Bank
A: Abundant R: Rare

Station	N. Latitude	E. longitude	Depth	Bottom deposit				Organisms	Date of collection	Position
				Rock	Gravel	Sand	Mud			
			m.							
St. 1	44057.5′	144011.8′	455		A				1951—	North. end
2	44 44.5	144 02.5	180			R	A		1944, Sept. 20	Continental shelf
3	44 47.4	144 08.7	202			R	A	R	1951	West side
4	44 46.8	144 15.0	165			R	A	R	1951	Center
5	44 45.9	144 20.8	185	A	A	A	R	R	1951	Center
6	44 32.2	144 14.0	140	A	A		R	R	1951	East side
7	44 28.0	144 02.5	180		R	A	A	R	1944, Aug. 20	West side
8	44 17.8	144 14.3	290		A		A	R	1944, Aug. 20	South side

b. Gravel. (Table III)

Gravel was obtained from five stations. The pieces of gravel are very round and will water worn. None was found to be striated or grooved. Some pieces were covered by organisms on one side so that they appear to have rested partly exposed on the sea bottom. The rock character of gravels can be classified into 1) old group (quartzite, greywacke sandstone, chert, granite, etc.), 2) young group (calcareous shale, sandstone, shale, etc.), 3) volcanic rock (andesite, liparite, etc.). These kinds of rocks were found in the Tertiary system or in the gravels in the Tertiary conglomerate on the adjascent land.

c. Sand and mud.

Sand and mud were obtained from st. 1, 3, 6, 9. The sand from st. 1 and 3 is very coarse and round, and the sand from st. 6 and 9 is very fine.

d. Organisms.

Organisms and organic remains are not so abundant, and, except for micro-organisms, are benthonic and deep sea types. The following species were determined, st. 5, *Venericardia ferruginea* Clessin (1 specimen); st. 7: *Limopsis crenata* A. Adams (1 specimen), *Lima* sp. (broken specimen), *Vermetus* sp. (broken specimen), *Craniscus japonicus* (A. Adams) (3 specimens); st. 8: *Venericadia ferruginea* Clessin (1 specimen), *Pseudoamsium* sp. (1 specimen), *Limopris crenata* A. Adams (1 specimen), *Astarte alaskensis* Dall (1 specimen), *Turcicula crumpii* (Pilsbry) (2 specimens), *Craniscus japonicus* (A. Adams) (1 specimen).

The number of the dredging stations is very small so that the bottom character of Mogami Bank is not clearly defined, but it is certain that the bed rock of this bank belongs to the Tertiary and gravel and sand or mud have been deposited on the flat plane. These characteristics are the same as those of the banks in the Japan. Sea.[1]

III. OKHOTSK YAMATO BANK.

Okhotsk Yamato Bank is situated 42°20'-44°57' N, 144°10'-144°30' E. along the outer margin of continental shelf off the northeast coast of Hokkaido.

1) H. NIINO: On the soundings from the banks between Oga Peninsula and Sado Island in the northeastern part of the Japan Sea. Jour. Imp. Fish. Inst. Vol. 31, No. 1. pp. 11–23, 1935.

Fig. 2 a. Okhotsk Yamato Bank

○ Dredged station ▲ Locality of bed rock

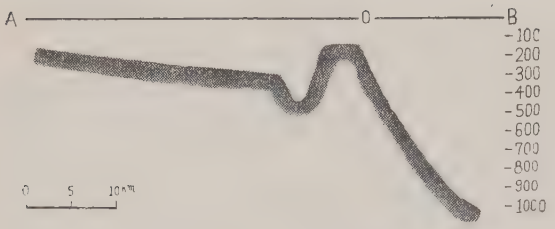


Fig. 2 b. (A–B) Section

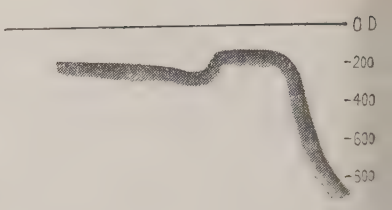


Fig. 2 C (C–D) Secrion.

During the years 1944 and 1951, Daishi Kaiyo maru of Hydrographic Office surveyed this bank and dredged at several stations. Tankai Maru of the Hokkaido Fisheries Experimental Station also surveyed this bank in the year 1945.

a) Submarine configuration of Okhotsk Yamato Bank.

The continental shelf along northeast coast of Hokkaido is very broad and its margin is in the direction north to south. Okhotsk Yamato bank is elevated along the east side of continental shelf divided by a trough below 200 m. The shape of the bank is narrow and elongate, 70 km. long to N–S, 5 km. wide E–W. The top of the bank is very flat and at a depth of 140–150 m., but the margin of the bank descends abruptly to the deep sea bottom. At the north and south margins of Okhotsk Yamato bank, there are developed submarine valleyes and at the heads of each of these valleyes is a small depressed area.

The shallowest point is 139 m. on the north part of the flat plane and 138 m. on the south part of the flat plane.

1. Bottom character (Table IV)

From chart No. 37 published by the Hydrographic Office and a map compiled by the Hokkaido Fisheries Experimental Station,[2] rocks are noted to be distributed on the flat plane, the steep slopes, and on the margin of continental shelf. Gravel is distributed on the flat plane and on the deep bottom near this bank. On the continental shelf, gravels are distributed sparsely. Sand and mud are distributed on the flat plane and steep slopes of this bank, on the deep bottom, and on the continental shelf.

Bottom samples were obtained by Daishi Kaiyo Maru at eight stations on and near this bank.

2) Preliminary report of deep sea expedition on fisheries ground. Hokkaido Fisheries Experimental Station special report, 1949.

Table V. Rocks from Okhotsk Yamato Bank

Station	Depth	Weight	Length	Width	Thickness	Addition of Organism	Rock character	Associate material with Rock	Position
	m.	g.	cm.	cm.	cm.				
St. 5	185	50	8.9	7.1	3.1	+	Marly shale	Gravel. Sand. Mud	North east part
6	140	30	5.5	4.3	3.4	+	Marly shale	Gravel	South east part

Table VI. Measurement of the largest price of gravel at each Station on Okhotsk Yamato Bank

Station	Depth	Largest price of gravel								Associated gravel	Position
		Weight	Length	Width	Thick-ness	Shape	Surface	Adhesion of organism	Rock character		
	m.	g.	cm.	cm.	cm.						
St. 1	455	0.2	0.7	0.55	0.5	Angular	Irregular	+	Sandstone	Chert. Shale	North dlep
6	140	13.0	3.5	2.0	1.2	Round	Smooth	+	Greywacke	Sandstone, Chert	On the bank
7	180	25.5	3.2	2.9	2.4	Sub round	Smooth	+	Granite	Sandstone, Hornstone	On the bank
8	290	35.0	6.0	5.1	3.7	Round	Smooth	+	Granite	Greywaeke, Hornstone	South dlep

Table VII. Bottom character of Frimo Bank
A: Abundant R: Rare

Station	N. Latitude	E. Longitude	Depth m	Bottom deposit					Date	Survey ship
				Total volum	Rock	Gravel	Sand, Mud	Organism		
St. 1	41°36′	143°38.0′	150	2 kg.	A	A	R	R	1951. Jan. 5	Umitaka
2	41 37.5	143 35.7	170	2 kg.	A	A	R	R	„	„
3	41 38.3	143;37.6	170	1 kg.	A	A		R	1951. Aug. 5	Seicho
4	41 37.3	143 37.0	155	500 kg.		A	A	R	1951. Nov. 8	Daishi Kaiyo

a) Rock (Table V)

Rocks were dredged from st. 5 and st. 6 on the flat plane of the bank. Organisms were found attached to the surfaces which were bored by organisms.

The rocks were exposed on the bottom but some parts were covered by gravel, sand and mud. Rock types are marly shale and calcareous sandy shale containing fossile *Forminifera*. The geological age is not cartain but the rock is very similar to the rocks on the Notori Peninsula, Hokkaido, or on the Shiretoko Peninsula, Karafuto which are Tertiary.

b) Gravel (Table VI)

Gravel was dredged from five station. The pieces of gravels are very round and well waterworn and have no striations or grooves on the surface. On some pieces, organisms were attached on one side only; indicating that the gravel was exposed on the sea bottom. The rock types in the gravels are; Chert, Hornstone and greywacke andstone. These types of rocks are found among the pebbles of the conglomerate gravel so that it is likely they were derived from Tertiary congrlomerate. Gravel composed of calcareous shale and marly shale is also found on the bank.

Gravels were also dredged from the deep sea floor around the bank, for examples st. 1 (455 m.) at the sea floor near the north margin of the bank.

c) Sand and mud.

Sand and mud were obtained from st. 1, 2, 3, 4, 6, 7 and st. 8. Sand grains dredged from st. 1, 2, 5, 7, 8 were coarse and round. These stations are situated on and near the bank. St. 2 and st. 3 are situated on the margin of continental shelf and sand grains from these stations were also coarse and round.

St. 4 is situated on the sea floor between continental shelf and bank and the bottom samples consist of fine tests of diatome and sponge spicules mixed with coarse sand grains. It is a notable fact that the grain sizes are large and very small and no medium sizes are present.

d) Organisms and oceanic condition.

Organisms were dredged from st. 5 and st. 8. *Bryozoa, Hydrozoa, Porifera,* and *Balanus* were very abundant. These sessile organisms are attached to the rock or gravel. One individual of living solitary coral was obtained from st. 5. Molluscs were very rare. The oceanic conditions observed at this bank as follows.

Okhotsk Yamato Bank lies along the margin of continental shelf, is oriented north to south, and is divided by a groove. The top of the bank is

a flat plane 150–160 m. in depth. The margin descends to deep floor with a steep gradient, more than 10 degrees.

Temperature of deep water at Okhotsk Yamato Bank.

North Latitude	East Longitude	Depth	Temperature	Date
44° 07.0'	144° 18.5'	35m.	18.56° C.	1944, Sept.20th
44 28.0	144 08.2	150	0.52	〃 〃
45 01.0	143 44.2	188	0.18	〃 〃
44 17.3	144 14.3	266	2.22	〃 〃

A rocky bottom is exposed on the bank and its steep slope. Gravel, sand and mud are distributed on the flat plane and its marginal slopes. The bottom character of the continental shelf on both sides of the bank are the same and the depth of the flat plane on the continental shelf is the same as the flat plane on the bank.

Therefore, it seems that the bank was isolated from the continental shelf before the time of cutting the flat plane on continental shelf or on the bank. The head of the submarine valley and the groove between the continental shelf and the bank received material eroded from the continental shelf and the bank. After the change of sea level the groove continued to receive eroded material to Recent time.

IV. ERIMO BANK.

Erimo Bank is situated on the sea bottom 30 km. off Erimo Peninsula, Pacific coast of Hokkaido. A narrow groove separates it from the continental shelf along Erimo Peninsula. This bank was surveyed by the Tankaimaru of Hokkaido Fisheries Experimental Station in 1947, the Daishi Kaiyomaru of Hydrographic Office in 1947 and 1949; and by the Seichomaru and Umitakamaru of Tokyo University of Fisheries in 1951. The data obtained by these surveys were gathered together by the outhor for a study of the fishing value of this bank. Erimo Bank lies between 41° 32' N.–41° 40' N, 143° 33' E–143° 50' E. The shape outlined by the 200 m. bathymetric line is an ellipse, long diameter 15 km., short diameter 3 km. At the east margin of this bank is a submarine valley with a tributary on the east slope of the bank. On the surface of the bank, is developed a broad and flat plane of 150–180 m. in depth. In the middle of the bank is a groove which divides the flat plane into two parts. The shallowest point is 153 m. in east and 166 m. in west. The slope around the bank is very steep and decends abruptly to the deep bottom below 800 m.

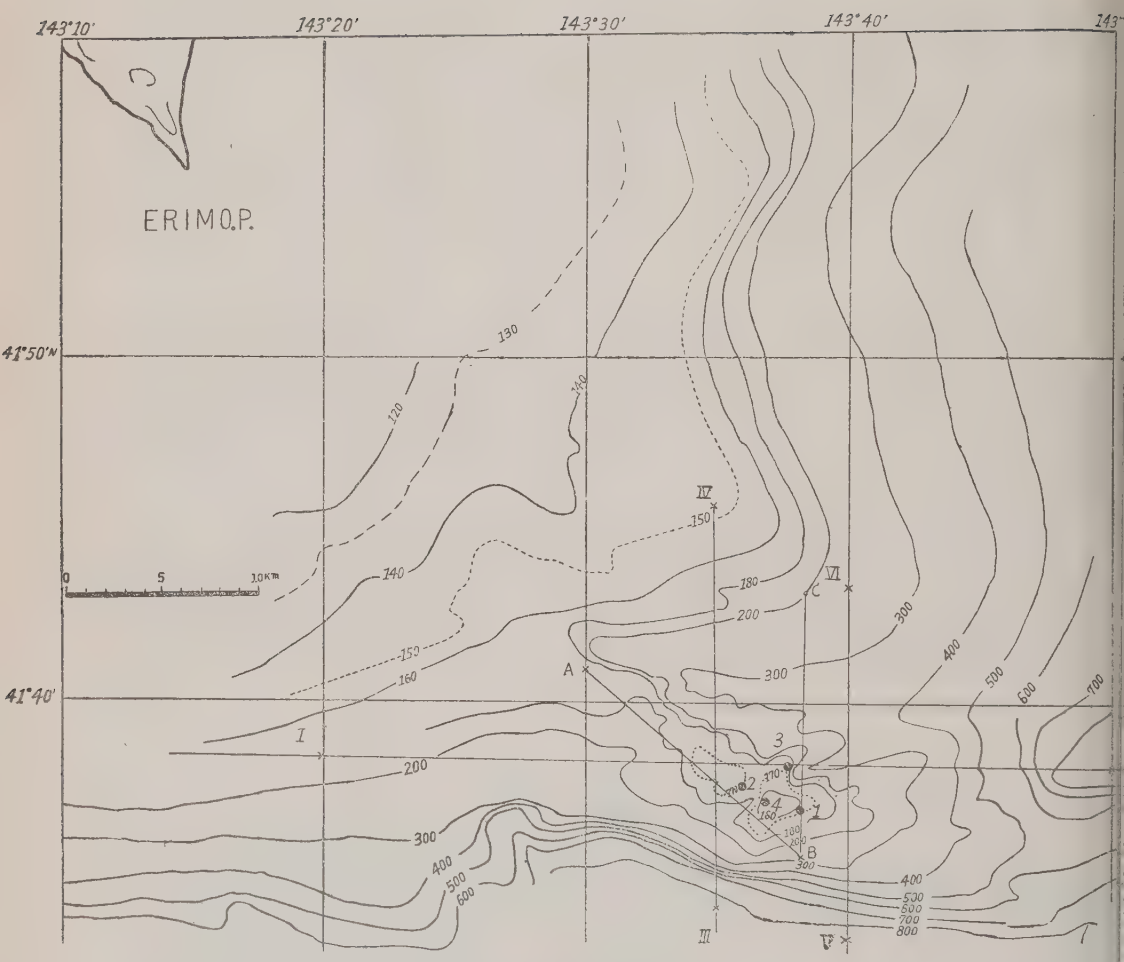


Fig. 3a. Erimo Bank, Hokkaido.

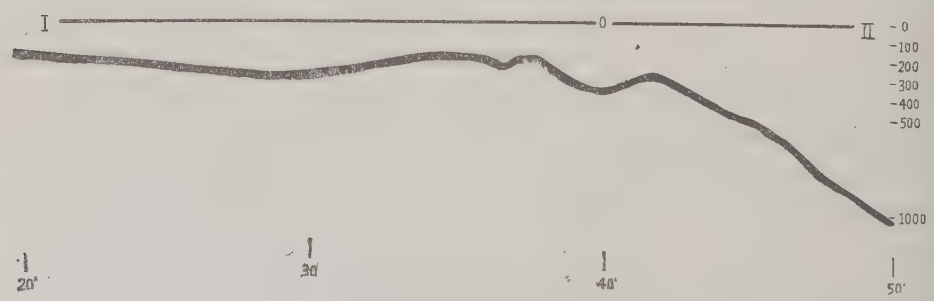


Fig. 3. b (I–II) Section of Erimo Bank

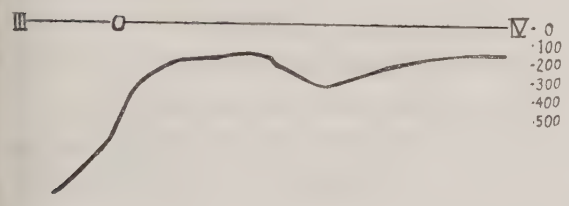


Fig. 3. c (III–IV) Section

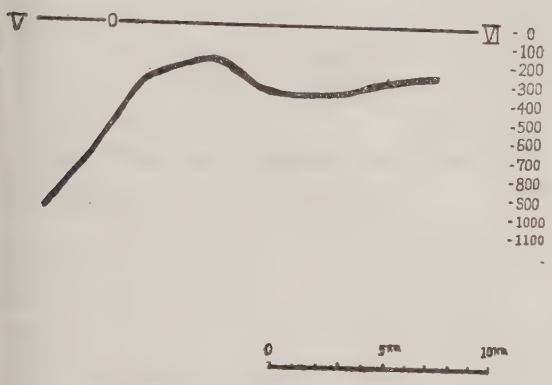


Fig. 3. d (IV–V) Section

1. Bottom character (Table VII)

The bottom character published by Hokkaido Fisheries Experimental Station shows that the gravel and rock are distributed on the flat plane and the steep slope around the bank.

The bottom sample were dredged from four stations and these samples were studied by the author.

a. Rock (Table VIII)

Rocks were dredged from st. 1, 2, 3, on the flat plane at the top of the bank. The surfaces of rock were bored by organisms and some holes were filled up by gravel and coarse

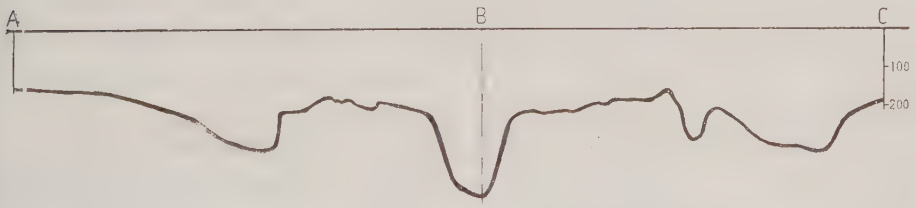


Fig. 3. e (A–B–C) Record of echo sounding which cross the Erimo Bank.

sand. Organisms were attached on the surface of the rocks. Therefore, the rock was exposed on the sea bottom and partly covered by gravel or sand.

In the sandy shale dredged from st. 1, there are found many fossil sponges of the species *Sagarite chitanii* Makiyama. This species is commonly found in the Neogene Tertiary rocks of Japan. Diatomaceous shale was also dredged from st. 3. Calcareous shale and conglomerate were dredged from st. 2 but do not contain fossils.

From the result of the geological survey around Erimo Peninsula, rocks of the Tertiary system are found near Samani villege far north of this bank.

b. Gravel. (Table IX)

Table VIII. Rocks dredged from Erimo Bank.

Station	Depth	Weight	Length	Width	Thickness	Hole bored by organism	Associated material	Rock character	Position
	m	g	cm	cm	cm				
St. 1	150	20.0	8.2	3.7	1.4	+	Gravel sand	*Sagarites* sandstone	East part
2	170	17.0	3.8	3.2	2.6	+	Gravel sand	Calcareous sandstone	West part
3	170	50.0	8.5	6.6	4.5	+	Gravel sand	*Sagarites* sandy shale	Center

Table IX. Measurement of the largest piece of gravel at each station on Erimo Bank.

Station	Depth	Weight	Length	Width	Thickness	Shape	Surface	Adhesion of organism	Rock character	Associated gravel	Position
	m	g	cm	cm	cm						
St. 1	150	50.0	5.6	4.9	4.1	Angular	Irregular	+	Granite	Greywacke. sandstone	South
2	170	35.0	6.7	4.8	3.4	Round	Smooth	+	Shale	Chert. Conglo. Granite	Nest
3	170	15.0	4.7	5.3	2.0	Round	Smooth	−	Sandstone	Greywacke. Chert	Center
4	155	10.0	4.5	2.5	2.2	Angular	Smooth	+	Chart	Granite. Conglomerate	Center

Gravels were dredged from four stations. The surface of the pieces of gravel are well waterworn and show no striation or grooves. Organisms are attached to one side of gravel and from this fact, it seems that the gravels rested exposed on the sea floor.

Rock types in the gravels are granite, chert, greywackes-andstone, and the kind of rocks found in the pebbles of conglomerate dredged from the bank. Tertiary shale and sandstone also make up the gravel. All the gravels dredged from the bank may have been derived from the basal Tertiary rocks.

c. Sand and mud.

Coarse well rounded sand was dredged from st. 1. The sand dredged from st. 4 was fine and silty and consisting of remains of *Diatom* and *Sponge*.

d. Organisms.

Many sessile organisms were found attached on the surface of rock and gravel as listed below:

St. 1 *Asterte alaskensis* Dall (5 specimens) *Priene oregonensis* Redfield (2 specimens) *Stylaster* sp. (abundant) *Bryozoa* (abundant) *Pecten* sp. (broken specimen) *Lepridozona* sp. (1 specimen) *Porifera* (abundant)

St. 2 *Limopris pelagica* smith (10 specimens)

These organisms show characteristics of a cold water fauna.

By the result of experimental fishing in the summer 1951; 64 percent of the number of hooks in a fishing wire get fishes.

V. CONCLUSION.

Three banks were discovered near the continental shelf of the Japanese Island, *i. e.* Mogami Bank, Japan Sea; Okhotsk Yamato Bank and Erimo Bank, off Erimo Peninsula.

These banks are elevated from the deep sea floor and are at the depth of 120–160 m.

A narrow groove separates the continental shelf from each bank.

On the top of the banks is developed a flat and broad plane, the depth of which is the same as the flat plane of the neighbouring continental shelf. The marginal slopes of the banks are abrupt and descend to deep sea floor at steep angles. The cross section profiles of the banks are asymmentrical.

The bed rock of the banks are Tertiary sedimentary rocks which are covered by a thin layer of gravel, sand and mud. Gravels are large and well waterworne and their rock types are the same as those the bed rock; they appear to have originated from the bed rock and not transported from the continental shelf across the groove.

The submarine configuration and the bottom character of those banks show the same characteristics as the tectonic banks which were reported around the Japanese Islands and described by the author. The discovery of those three banks added valuable data toward the solution of geological problems of the Japanese Islands and also contributed valuable data for the fisheries of Japan.

The author appreciate this opportunity to express his sincere thanks to the members of the Umitakamaru and the Seichomaru, of the training ship of Tokyo University of Fisheries, and the Daishi Kaiyomaru of Hydrographic

3) T. NAGAO: Preliminary report on the Mesozoic and Tertiary system of West Hidaka range. Jour. Geol. Soc. Japan. Vol. 43, pp 394–401, 1931.

4) K. IGARASHI: Geology of Hidaka district. Graduation thesis of Geological department of Tohoku University, 1931.

5) M. MINATO and R. URANO: Tertiary geology of Shizunai district Hidaka Provice, Hokkaido. Shinseidai Kenkyu No. 6, 1950.

Office. At the time of survey of the banks the author received kind assistance from those members.

In the writing of the result of this study, I received invaluable help from Mr. C. G. Johnson of the Geological Survey U. S. A.

This survey was undertaken by a financial assistance (1950–1951 A. C.) from Kagaku Kenkyuhi of Educational Department.

PLATES

PLATE I.

Rock, gravel and organisms dredged from Okhotsuk Yamato Bank.

Fig. 1. Rock fragment dredged from 44° 45.4' N. 144° 20.8' E. 185m.
Left side: *Stylaster* sp. attached on carcareous shale
Center: *Hyodrozoa* attached on sandy shale.
Right side: *Bryozoa* attached on conglomerate.

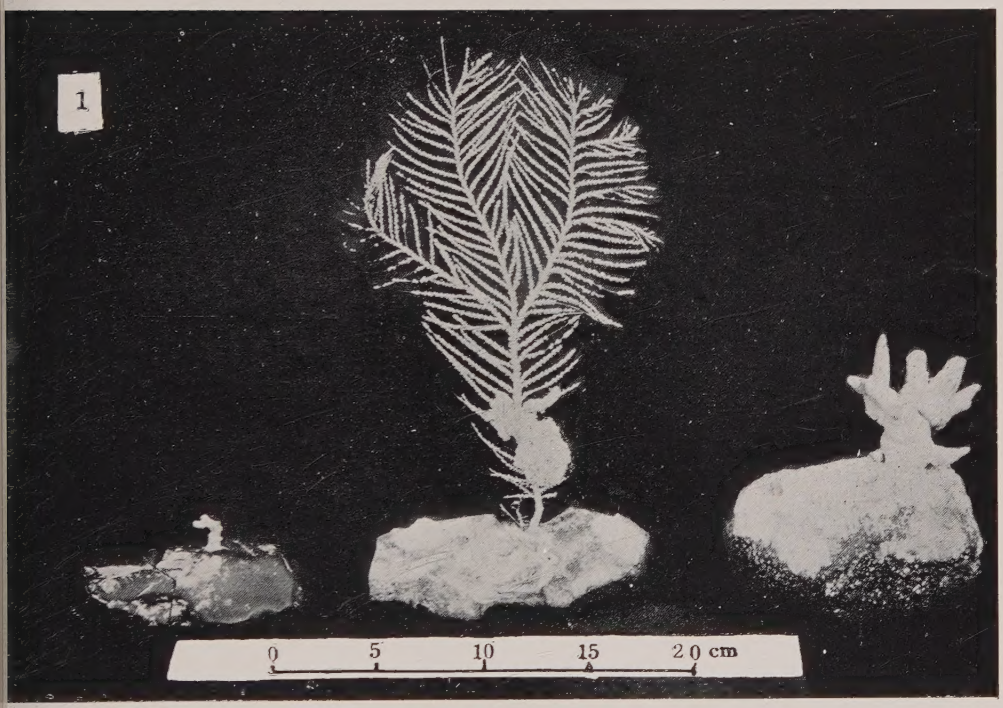
Fig. 2. A fragment of marly shale. Same station to Fig. 1.

Fig. 3. Gravel of greywacke sandstme. organisms attached on the surface. Same station Fig. 1.

Fig. 4. Gravel cemented togather by sponge. Same station Fig. 1.

Fig. 5. *Flavellum* sp. (cfr. *transversale conicum* Yabe et Eguchi) Same station Fig. 1.

Fig. 6. 7. *Limposis* sp. Same station Fig. 1.


1
0 5 10 15 20 cm

4
2
5
0 1 2 3 4 cm
0
1 cm
2
3
6
7

PLATE II.

Rock and gravel dredged from newly discovered bank.

Fig. 1. Diatomaceous shale dredged from Erimo Bank, St. 1 41° 36' N. 143°38' E. 150 m.
S: fossil sponge *Sagarites chitanii* Makiyama contained in the rock. This fossil is commonly found in the Neogene Tertiary in Japan.

Fig. 2. Diatom earth from Mogami Bank, Japan Sea.
39° 10.8' N. 138° 51.8, E. 240 m.

Fig. 3. Fragment of sandy shale from Erimo Bank.
41° 38.3' N. 143° 37.6' E. 170 m.
Lepridozona sp. attached on the surface.

Fig. 4. Gravel dredged from Eriono Bank. Station: Same station to Fig. 3.

PL. II.